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Design and Fabrication of a Low-Cost, Manual Groundnut Peeler machine for Small-Scale Farmers

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Abstract - *The Design and Fabrication of a Modified Groundnut Peeler Machine aims to provide a cost-effective, manually operated solution to meet the needs of small-scale farmers and businesses. Existing groundnut peeling machines are often expensive, reliant on electricity, and unsuitable for use in remote areas. This project introduces an innovative design incorporating a handwheel and Crank and Slotted Lever Mechanism, which effectively reduces human effort and minimizes operator fatigue.The machine features an adjustable peeling mechanism to accommodate various groundnut sizes, ensuring flexibility and efficiency across different varieties. Its compact and portable design makes it easy to transport, assemble, and use, providing an affordable alternative to traditional motorized peelers. The simplicity of the design also ensures low maintenance and accessibility for rural and small-scale operations.Future enhancements include integrating a chain and sprocket mechanism for smoother operation or motorization to further reduce manual effort. The machine can even be adapted as an exercise device, offering multifunctionality.*

Key Words: Groundnut, pee Machine, Efficiency, Design, Calculations, Fabrication, Assembling, Evaluation, Modification.

1. INTRODUCTION

Groundnut peeling is a critical stage in post-harvest processing, particularly for small-scale farmers and rural communities. Efficient peeling not only impacts productivity but also determines the overall profitability of groundnut cultivation. However, existing peeling machines are often expensive, heavily reliant on electricity, and unsuitable for small-scale applications due to their bulky designs and operational complexity [1]. These limitations are particularly challenging for farmers in remote areas where access to electricity and high-end machinery is restricted. This study focuses on addressing these issues by designing and fabricating a manually operated groundnut peeler machine that is cost-effective, portable, and easy to operate. The proposed machine is specifically tailored to meet the needs of small-scale farmers, providing a practical solution that eliminates the dependency on electricity while improving productivity. By incorporating a handwheel-driven mechanism, the machine simplifies operation, reduces physical strain, and ensures efficient peeling. The compact and lightweight design, combined with the use of locally available raw materials, further enhances its affordability and adaptability. The primary objective of this project is to develop an innovative groundnut peeling solution that integrates mechanical efficiency, portability, and ease of use. The machine's design aims to bridge the gap between high-end, motorized solutions and manual methods, thereby empowering farmers to optimize their post-harvest processes [2]. Through this research, we aim to contribute to the advancement of agricultural technologies that cater specifically to the needs of small-scale farmers and rural communities.

2. CONCEPT DEVELOPMENT

Develop a conceptual design for a hand-operated groundnut peeling machine that includes a handwheel and a crank and slotted lever mechanism [3]. The design will emphasize simplicity, compactness and ease of use, making it ideal for small businesses and farmers. The machine will be easy to assemble and disassemble, allowing convenient transportation, storage and maintenance.

To accommodate different sized ground nuts, the peeling mechanism will be adjustable, ensuring optimum performance for different types of ground nuts. The design will also focus on reducing human effort and reducing unnecessary movements to avoid user fatigue, ensuring comfortable and efficient operation for long periods of time. Crank and Slotted Lever Quick Return Mechanism is mostly used in shaping machines, slotting machines and in rotary internal combustion engines [4]. Using this mechanism we can increase effective working time [5].

Figure 2.1: Groundnut peeling machine

3. WORKING PRINCIPLE

The modified groundnut peeler machine operates using a combination of a handwheel and a crank and slotted lever quick return mechanism. This setup is designed to efficiently peel ground nuts with minimal effort.

Operation steps:

- The operator turns the handwheel, which initiates the motion of the crank.
- As the handwheel turns, the crank rotates, and the slotted lever mechanism converts this rotational motion into a linear back-and-forth (reciprocating) motion.
- The reciprocating motion drives the peeling mechanism within the shelling chamber. The ground nuts are fed into the machine, and the pods are broken by the shelling mechanism.
- The machine includes an adjustment mechanism that allows the operator to set the peeling gap according to the size of the ground nuts. This ensures effective peeling for various ground nuts.
- As the peeling occurs, the shells are separated from the nuts. The peeled nuts are then collected in a separate chamber, while the discarded shells are ejected.
- The peeled groundnuts are collected in a separate chamber, ready for further processing or consumption. The quick return mechanism ensures that the process is efficient, with a rapid cycle of peeling and separation.

4. CALCULATION:

- Force and Torque Calculations: Determine the required force to operate the handwheel effectively. Calculate the torque needed to convert the rotary motion into oscillating motion using the Crank and Slotted Lever Mechanism [4]. These calculations will ensure that the machine is easy to operate while maintaining high efficiency.
- Material Stress Analysis: Perform stress analysis on the selected materials to ensure they can withstand the operational loads. This will include calculations for the mechanical properties of the materials, such as tensile strength, yield strength, and fatigue limits [5].
- Efficiency and Output Rate Calculations: Estimate the peeling efficiency and output rate of the machine. This will involve calculating the number of ground nuts that can be processed per unit of time, considering the speed of operation and the effectiveness of the peeling mechanism.

To determine the stresses, forces, shear force diagram (SFD), and bending moment diagram (BMD) for the described rotary lever mechanism, we can break the system into key components:

a) Handwheel (Handle)

b) Shaft

c) Pin

d) Slotted-lever mechanism

e) Crank

Here's how we can approach the problem step by step:

Determine the required force to operate the handwheel effectively. Calculate the torque needed to convert the rotary motion into oscillating motion using the Crank and Slotted Lever Mechanism.

a) Forces Acting on the Hand wheel (Handle)

- A human applies a force (F) = 250 N at the handle. [6]
- The distance from the center axis of the lever to the center axis of the shaft is now R = 150 mm = 0.15 m.
- $T\,(lever) = F \times R = 250 \times 0.15 = 37.5\,Nm$ [7]

b) Handwheel Shaft Forces and Stresses

- Diameter of the shaft = 20 mm
- The same torque applied by the lever is transferred to the crank through the shaft.

T Shaft = 37.5 Nm

- We calculate the shear stress using the torsion formula [10]

$$\tau = \frac{T\,(Shaft) \times r}{J}$$

Where:

τ = Shear Stress

r = Shaft radius = 10mm = 0.01m

J = Polar moment of inertia

$$J = \frac{\pi d^4}{32}$$

$$J = \frac{\pi \times 0.01^4}{32} = 1.571 \times 10^{-9}$$

$$\tau = \frac{37.5 \times 0.01}{1.571 \times 10^{-9}} = 23.87\,MPa$$

c) Pin Forces

- Considered Pin diameter = 10 mm.
- Stresses developed in pin

$$\tau = \frac{F\ (pin)}{A\ (pin)} = \frac{250}{7.854\ \times 10^{-5}} = 3.18\ MPa$$

d) Stresses slotted leaver (Shear Force in the Slot) [7]

$$F = \frac{T\ (crank)}{r\ (crank)} = \frac{37.5}{0.055} = 681.81\ N$$

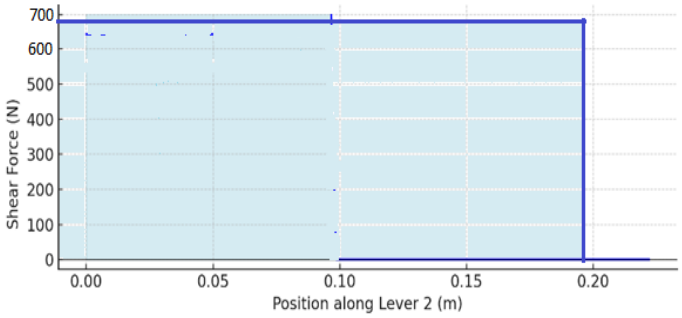

Figure 4.1: Shear Force Diagram (SFD)

e) **Crank Forces and Stresses (**Bending Moment on the crank) [7]

$$M\ (crank) = F\ (pin)\ \times r\ (crank)$$

$$M = 250\ \times 0.055 = 13.75\ Nm$$

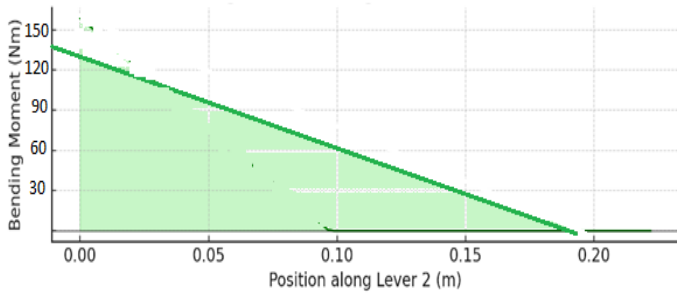

Figure 4.2: Bending Moment Diagram (BMD

- Shear Force Diagram (SFD): The shear force starts at its maximum value (545.45 N) at the pivot point of Lever 2 and decreases to zero as we move towards the slot where the crank pin slides.
- Bending Moment Diagram (BMD): The bending moment is highest near the pivot point of Lever 2 (52.91 Nm) and decreases to zero towards the slot where the crank pin acts.

Table -1: Force required for peeling

No of Pods		10	No.
Peeling strength	Ps	0.035	N/mm2
Surface Area of groundnut seeds	Ag	120	mm2
Peeling Force for 1 Pod [8]	Fg	4.2	N
Force required for 10 Pods		42	N
Weight of 1 Pod [2][8]		1.17	g
Weight of 10 Pods		11.7	g
Force required to peel 1 pod [2]		57	N
Force required for 10 Pods (As per Paper)		570	N

Table 2: Force Generated by Machine

Force on the Handwheel	250	250	N
Handwheel Radius	150	0.15	m
Crank Radius	55	0.055	m
Total lever length	195	0.195	m
Lever length from Piot point slot	110	0.11	m
Slot length	150	0.15	m
Torque from Handwheel		37.5	Nm
Force at Crank		681.82	N
Force req. for peeling 10 seeds (Force calculated by formula)		42	N
Force required		570	N
Generated Force by Machine		681.82	N
Factor of safety		1.20	
In one min. our machine can crush 250 to 400 g			
Our Machine can Peel dry Groundnuts in Hr		15 to 20 Kg	

✓ *The force applied by the handwheel (250 N) combined with the crank mechanism generates a force of 681.82 N at the peeling point, sufficient to peel 10 ground nuts simultaneously.*

✓ *These calculations will ensure that the machine is easy to operate while maintaining high efficiency.*

5. STRESS ANALYSIS (Simulations):

Perform stress analysis on the selected materials to ensure they can withstand the operational loads. This will include calculations for the mechanical properties of the materials, such as tensile strength, yield strength, and fatigue limits.

As per got results our crank assembly will withstand for the 620N

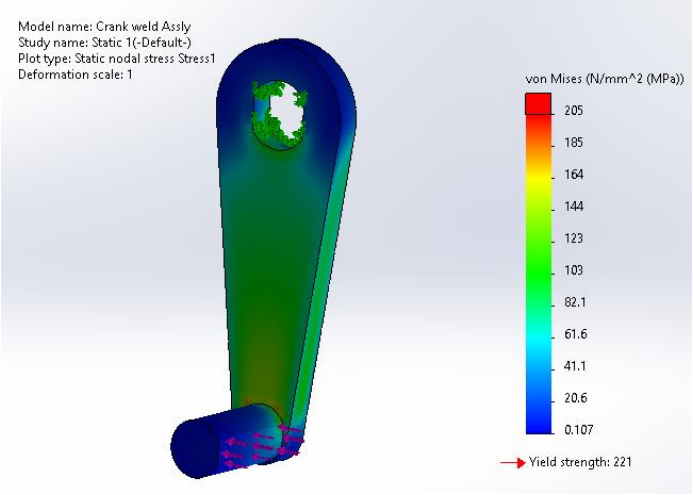

Fig -5.1: Stresses developed in Crank

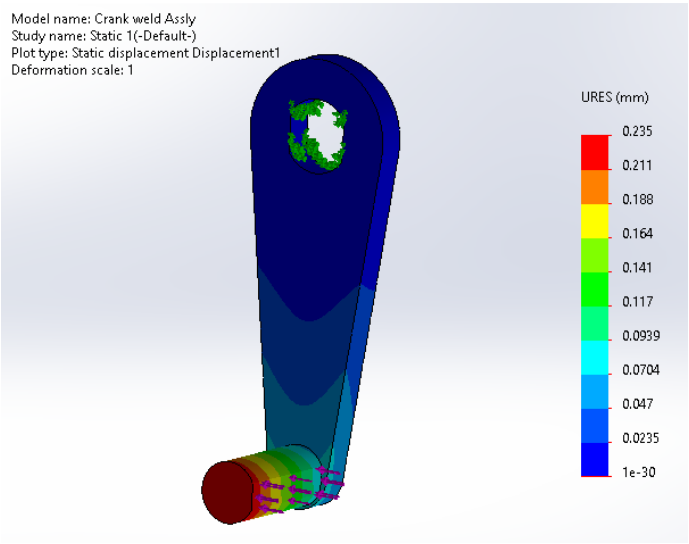

Fig -5.2: Displacement

6. CONCLUSIONS

The Design and Fabrication of a Modified Groundnut Peeler Machine successfully addresses the challenges associated with traditional groundnut peeling methods and existing machines. The manually operated machine, utilizing a handwheel and Crank and Slotted Lever Mechanism, offers a cost-effective, compact, and efficient solution tailored for small-scale farmers and businesses. Its design focuses on reducing hu-man effort, increasing portability, and eliminating the need for electricity, making it ideal for remote locations.

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