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Design And Development of Automatic Coconut Harvester

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Abstract: *Manual coconut harvesting involves high physical effort, safety risks, and dependency on skilled climbers. This research presents the design and development of a low-cost coconut harvesting machine based on a three-wheel climbing mechanism using a mild steel frame and spring-loaded adaptive gripping system. The developed prototype consists of motorized climbing wheels, a cutter mechanism, Arduino based control system, and battery power supply. The spring mechanism maintains continuous contact between the wheels and tree trunk during variation in diameter. Mechanical analysis including climbing force, wheel torque, power requirement, battery performance, and structural strength analysis is carried out to validate the proposed design.*

Keywords: *coconut harvesting*

I. INTRODUCTION

Coconut cultivation plays an important role in agriculture and provides economic benefits through coconut-based products. Traditional coconut harvesting mainly depends on skilled climbers who manually climb tall trees and cut coconut bunches. This process involves high physical effort, safety risks, and dependency on labour availability.Automation in agriculture provides an opportunity to reduce human involvement in risky operations. Existing robotic coconut harvesting systems often involve complex mechanisms, high manufacturing cost, and advanced control systems. Therefore, a simple, economical, and reliable mechanical solution is required.

RESEARCH GAP

Existing coconut harvesting systems generally use complex robotic mechanisms and increase manufacturing cost. The proposed system focuses on a simple three-wheel mechanical climbing arrangement with spring assisted gripping, making it suitable for low-cost agricultural automation.

OBJECTIVES

- To design and develop a coconut tree climbing and harvesting machine.
- To reduce human risk during coconut harvesting.
- To develop a three-wheel gripping mechanism for tree climbing.
- To design a low-cost mild steel structure.
- To analyze motor torque and mechanical performance.

PROPOSED SYSTEM DESIGN

The developed system consists of a mild steel frame, three motorized wheels, spring adjustment mechanism, cutting unit, battery supply, and control system.

The three wheels provide three-point contact with the tree trunk. The spring mechanism allows movement according to variation in tree diameter and maintains gripping force.

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SYSTEM COMPONENTS

The developed machine consists of:

- Mild steel square channel frame
- Three rubber climbing wheels
- 12V DC geared motors
- Spring loaded wheel adjustment mechanism
- Arduino Nano controller

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- L298N motor driver
- HC-05 Bluetooth module
- Li-ion battery system
- 775 PMDC cutter motor
- Cutter wheel

WORKING PRINCIPLE

The machine is placed around the coconut tree trunk. The three wheels maintain contact with the tree surface. Motor torque rotates the wheels and produces upward climbing motion through friction. Springs provide adaptive pressure and prevent wheel slipping. After reaching the required height, the cutter motor rotates the cutting wheel to remove coconuts.

CONTROL SYSTEM

The control system consists of Arduino Nano, Bluetooth module, and motor driver. Commands from the user are transmitted through Bluetooth and processed by the controller to operate climbing motors and cutter mechanism.

BILL OF MATERIALS

The major components include MS frame, motors, motor driver, Arduino Nano, Bluetooth module, wheels, springs, battery, cutter motor, and cutter wheel.

MATERIAL SELECTION

Mild steel is selected for the frame because of its high strength, weldability, availability, and low cost. The frame provides structural support for motors and other components.

DESIGN CALCULATIONS

Design Data

The following design parameters were considered for the calculation of the Automatic Coconut Harvester.

Machine Weight = 12 kg
Acceleration due to Gravity (g) = 9.81 m/s^2
Number of Wheels = 3
Wheel Diameter = 70 mm
Wheel Radius = 35 mm = 0.035 m
Battery Voltage = 12 V
Battery Capacity = 5000 mAh
Frame Material = Mild Steel
Density of Mild Steel = 7850 kg/m^3
Cross Section of Square Tube = 20 mm × 20 mm × 1.5 mm

Frame Weight Calculation

Given Data Outer Side = 20 mm
Wall Thickness = 1.5 mm
Inner Side = 20 − 2(1.5) = 17 mm

Cross Sectional Area

A = Outer Area − Inner Area
$A = 20^2 - 17^2$

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$A = 400 - 289$
$A = 111\ mm^2$
$A = 111 \times 10^{-6}\ m^2$

Length of Frame Members
Upper Hexagon = $6 \times 0.4 = 2.4$ m
Lower Hexagon = $6 \times 0.4 = 2.4$ m
Vertical Members = $6 \times 0.25 = 1.5$ m

Total Length
$L = 2.4 + 2.4 + 1.5$
$L = 6.3$ m

Volume of Frame
$V = A \times L$ $V = 111 \times 10^{-6} \times 6.3$
$V = 0.000699\ m^3$

Mass of Frame
Mass = Density × Volume
Mass = 7850×0.000699
Mass = 5.49 kg

Frame Weight
$W = mg$
$W = 5.49 \times 9.81$
$W = 53.85$ N
Frame Weight = 5.49 kg

*** Total Machine Weight**

Component	Weight (kg)
Frame	5.49
Geared Motors	1.50
Wheels	0.60
Springs	1.20
Battery Pack	0.50
Cutter Motor	0.35
Electronics	0.80
Fasteners	1.00

Total Weight = 11.44 kg
Design Weight ≈ 12 kg

Climbing Force Calculation
The climbing force required is equal to the weight of the machine.

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Weight Force
F = mg
F = 12 × 9.81
F = 117.72 N
Considering friction and transmission losses of 20%

Required Force
F = 117.72 × 1.2
F = 141.26 N
Required Climbing Force = 141 N

Force on Each Wheel
Number of Wheels = 3
Force per Wheel
Fw = Total Force / Number of Wheels
Fw = 141 / 3
Fw = 47 N
Force on Each Wheel = 47 N

Torque Requirement
Wheel Radius
r = 35 mm = 0.035 m
Torque
T = F × r
T = 47 × 0.035
T = 1.645 Nm
Required Torque = 1.65 Nm ≈ 1.7 Nm

Power Requirement
Assume climbing speed
V = 0.15 m/s
Power
P = F × V
P = 141 × 0.15
P = 21.15 W
Considering transmission losses
P = 21.15 × 1.5
P = 31.72 W
Required Power ≈ 35 W

Battery Backup Calculation
Battery Voltage
V = 12 V
Battery Capacity
Ah = 5 Ah

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Battery Energy
E = V × Ah
E = 12 × 5
E = 60 Wh

Power Consumption
P = 35 W
Battery Backup
Time = Energy / Power
Time = 60 / 35
Time = 1.71
Hours Battery Backup ≈ 100 Minutes

Spring Force Calculation
Number of Springs = 3

Total Load
F = 117.72 N

Load per Spring
Fs = 117.72 / 3
Fs = 39.24 N

Spring Force ≈ 40 N per Spring
This force is sufficient to maintain continuous wheel contact with the tree surface.

Factor of Safety
Yield Strength of Mild Steel
σy = 250 MPa

Assumed Working Stress
σw = 80 MPa
Factor of Safety
FOS = σy / σw
FOS = 250 / 80
FOS = 3.125

Factor of Safety
FOS = 3.12
Since FOS > 2, the design is safe.

EXPERIMENTAL EVALUATION
The prototype should be evaluated based on:
• Tree diameter adaptability
• Climbing stability
• Wheel gripping performance

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- Cutting operation
- Battery performance

II. RESULT & DISCUSSION

The developed prototype demonstrates the feasibility of a low-cost coconut harvesting system. The three-wheel mechanism provides stability, while the spring arrangement improves adaptability. The structural analysis confirms that the mild steel frame provides sufficient strength for the application.

ADVANTAGES

- Low manufacturing cost
- Simple fabrication
- Reduced human risk
- Easy maintenance
- Suitable for agricultural applications

LIMITATIONS

- Limited battery operating time
- Requires further field testing
- Prototype speed optimization is required

APPLICATIONS

- Coconut plantations
- Agricultural automation
- Palm tree maintenance
- Small-scale farming applications

FUTURE SCOPE

- Automatic coconut detection using camera
- IoT based monitoring
- Solar charging system
- Lightweight material optimization

III. CONCLUSION

A three-wheel based coconut harvesting machine was successfully designed and developed. The system reduces manual climbing risk and provides a simple mechanical automation solution for agricultural applications.

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