Design and Manufacturing of Solar Operated Agriculture Crop Cutter

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***Abstract*—This report represents the project work carried on development of Design and Manufacturing of Solar Operated Agriculture Crop Cutter. We have developed a compact mechanism for harvesting of crop. Cutter work on solar power so that we can an easily harvest crop in minimum period of time. This set up is used to cut the multi-crops at a time, which helps the small-scale farmers. This set up uses the solar power, which is provided with different blades, solar plate, rubber wheel, DC motor and battery arrangement which results in transmission of this solar power into rotary motion of cutter at the end of which the crops get cut easily and perform various task as per requirement. We have made changes in the existing machine to make its application easier at reduced cost. Our main aim in designing and manufacturing of Design and Manufacturing of Solar Operated Agriculture Crop Cutter is attained through this project work. The solar operated crop-cutter is based on the principle that it uses the flat plate solar collector to generate the energy needed to power the mower. It is assumed that a crop-cutter using solar as the energy source will address a number of issues that the standard I C Engine and crop-cutter worked on electric motors do not. A crop-cutter with solar energy will be easier to use, it eliminates down time and also it is user friendly. Design and Manufacturing of Solar Operated Agriculture Crop Cutter can be described as the application of conversion of solar energy to electric energy and applied to motor which revolve a blade which does the cutting of crop. Solar energy is the renewable energy. We are developing such crop cutter which has easy to use. We are going to use solar energy to generate power which is stored in form of battery. This supply is distributed in all section as per our requirement. Using Flat Plat Solar Collector panel generate the energy needed to power the cutter. The dangerous emissions produced by the gasoline spillage in that of the IC Engine into the atmosphere are also eliminated.**

Index Terms—Solar energy, Crop cutter, Agricultural machinery, Sustainable farming, Design and fabrication

I. INTRODUCTION

The basic objective of this project work is to develop compact multi- crop cutter operated on electric motor running through a solar energy. By implementing this project, we can eliminate a lot of difficulties in agriculture sector. Power plays a great role wherever man lives and works. The living standard and prosperity of any nation vary directly with the increase in the use of power. The electricity requirement of the world is increasing at an alarming rate due to industrial growth, increased and extensive use of electrical gadgets.

In this context, today's, best alternative source is solar energy. A solar operated crop-cutter was developed on the principle of grass mowing. The sun provides sustainable amount of the energy used for various purposes on earth for atmospheric system. The total solar energy is estimated to be 30,000 times greater than the total annual energy of the world. The solar powered Multi crop-cutter is based on the same principle that other early inventions of crop-cutter work on. It uses the Flat plate solar collector to generate the energy needed to power the mower. It is assumed that a crop-cutter using solar as the energy source will address a number of issues that the standard IC Engine and crop-cutter worked on electric motors do not. A crop-cutter with solar energy will be easier to use, it eliminates down time and also it is user friendly.

Design and Manufacturing of Solar Operated Agriculture Crop Cutters can be described as the application of solar energy to electric energy converted and applied to motor which revolve a blade which does the cutting of crop. Solar energy is the renewable energy. We are developing such crop cutter which has easy to use. We are going to use solar energy to generate power which is stored in form of battery. This supply is distributed in all section as per our requirement. Using Flat Plat Solar Collector panel generate the energy needed to power the cutter. The dangerous emissions produced by the gasoline spillage in that of the IC Engine into the atmosphere are also eliminated.

II. NECESSITY OF THE PROJECT

Reduction in Labor Costs: Traditional crop harvesting requires significant manual labor, leading to increased operational costs, especially during peak harvest seasons. A solar-operated crop cutter can drastically reduce dependency on manual labor.

Sustainability: As global energy demands rise and fossil fuel resources become more strained, there is a growing need for renewable energy-powered devices. Solar energy is an ideal alternative, especially for rural agricultural areas with ample sunlight but limited access to grid electricity.

Accessible to Small Farmers: In developing countries, many small-scale farmers lack access to expensive mechanized equipment. This project aims to develop a low-cost, sustainable crop cutter powered by solar energy, making it accessible to even marginal farmers.

III. OBJECTIVES

- To design solar operated agriculture crop cutter for soyabean, wheat and rice.
- To manufacture solar operated agriculture crop cutter for soyabean, wheat and rice.

IV. LITERATURE REVIEW

In India, agriculture plays a central role in rural livelihoods, yet mechanization is still underdeveloped in many regions, particularly among small-scale farmers. Manual harvesting methods are labor-intensive, time-consuming, and inefficient. In this context, solar-operated and manually powered crop cutters have emerged as promising alternatives to improve productivity, reduce dependency on labor, and lower operational costs. This literature review explores innovations in low-cost, energy-efficient crop cutters, highlighting developments in design, functionality, and applicability.

1. Manually Operated Crop Cutters

Komawar et al. [1] introduced a manually operated multi-crop cutter designed with sprockets, bevel gears, and chain transmission. Their system converted the manual push of the operator into rotary motion, effectively driving the cutting mechanism. The simplicity and affordability of the design make it suitable for rural farmers with small landholdings. Gupta et al. [2] developed a similar solution using a crank and lever mechanism, further simplifying the design while improving reliability in cutting cereal crops with slender stems. These designs reduce fatigue and allow for faster operation compared to traditional sickles. D'Souza et al. [4] proposed a multipurpose manual crop cutter based on a slider-crank mechanism. The incorporation of bevel gears and a simple chassis enabled the efficient harvesting of paddy, wheat, and grasses. Their machine was notable for its portability, ease of maintenance, and ergonomic handling, which made it particularly suitable for aged or unskilled laborers.

2. Mechanically Assisted Motorized Systems

Shinde et al. [3] presented the PASMA multi-crop cutter, which employed a scotch yoke mechanism and was powered by a compact gasoline engine. Their design was tailored for intercrop fields and emphasized precision and efficiency in cutting various types of crops.

3. Comparative Advantages and Limitations

All the reviewed technologies aim to reduce labor intensity and increase the efficiency of harvesting operations. Manual systems are low-cost and simple but may lack consistency in large-scale use. Solar-operated models offer environmental and cost benefits but are limited by weather conditions and initial cost of photovoltaic components. Motorized cutters strike a balance by enhancing throughput, although they still require fuel or electricity and more complex maintenance. Common challenges include field irregularities, crop height variations, and the need for adjustable cutting height. Future improvements may focus on smart automation, AI-integrated cutting paths, and hybrid power sources.

V. SYSTEM DEVELOPMENT

A. MAIN COMPONENTS OF SOLAR OPERATED CROP CUTTER ARE

1. Solar Panel

Overview: The solar panel is an essential component that captures solar energy and converts it into electrical energy. This renewable energy source makes the crop cutter efficient and eco-friendly, reducing dependence on conventional fuels. Solar panels are ideal for use in agricultural fields where sunlight is abundant.

2. Charge Controller

Overview: The charge controller is an essential component in solar-powered systems. It regulates the flow of electricity from the solar panel to the battery, ensuring the battery is charged efficiently and protected from overcharging, which can damage the battery and shorten its lifespan. The charge controller also prevents the battery from discharging excessively.

3. Battery

Overview: The battery stores energy generated by the solar panel, ensuring that the crop cutter can function even when there is no sunlight. This makes the system reliable for extended periods.

4. DC Motor

Overview: The DC motor converts electrical energy from the battery into mechanical energy to drive the crop-cutting mechanism. It is a vital part of the system, ensuring efficient cutting performance.

5. Scotch Yoke Mechanism

Overview: The Scotch yoke mechanism is a mechanical system used to convert rotary motion into linear reciprocating motion. It is commonly employed in systems requiring a simple and compact design for converting motor rotation into straight-line movement. In agricultural equipment, it can be used to drive linear cutting blades or actuators with consistent motion and force.

6. Cutting Blade

Overview: The blade is responsible for cutting the crops. It needs to be made from high-strength and corrosion-resistant materials to ensure longevity and effectiveness.

7. Switches and Controls

Overview: Switches and controls manage the operation of the crop cutter, making it easy for the user to power it on and off and adjust the motor speed.

8. Frame

Overview: The frame provides structural support for all components, ensuring stability and durability. It must be designed to withstand rough terrain and outdoor conditions.

9. Handle

Overview: The handle allows the user to maneuver and control the crop cutter. Ergonomic design is crucial to reduce operator fatigue.

10. Wheels

Overview: Wheels allow the crop cutter to move easily across the field. They must be designed to handle various terrains, from dry soil to muddy fields.

B. Design Calculation

Design calculation is performed according to the need of the customer keeping in mind the safety of the farmer and to design an effective model with all requirement of the farmer. This information provides a guide to the crop's physical properties, field irregularities, and ideal cutting height for efficient manufacturing and operation.

Soyabean field survey

Plant Height: 60 - 100 cm (varies with variety and growth conditions)
Spacing:
Between Rows: 30 - 45 cm
Between Plants: 5 - 10 cm
Stem Thickness: 2 - 5 mm (varies depending on variety and maturity stage)
Optimal Blade Cutting Height: 5 - 10 cm from ground level to ensure most pods are harvested without excess soil or debris.

Calculations of blade:

Blade Design (using reference Soybean)

Blade Geometry
Cutting Angle: Optimal Cutting Angle: 50°.
Rationale: A sharper angle 50° ensures an effective cut with minimal force while preventing excessive wear on the blade.

Dimensions of the Blade:
Length of Blade: 600 mm (depending on the width of the cutter and to ensure coverage of a row of plants in one pass).
Width of Blade: 100 mm
Blade Thickness: 3 mm (for maintaining sufficient strength and reducing the risk of breakage).

Load Calculation on Cutting Blade
Parameters for Calculation
Stem Thickness (Diameter): 3 mm (for mature soybean plants)
Yield Strength of Soybean Stem Material: 1.8 Mpa rough estimate for the fibrous nature of the stem

Calculation Steps:
Cross Section area of soyabean one steam

$$\text{Area} = \pi \left(\frac{d}{2}\right)^2$$

$$\text{Area} = \pi \left(\frac{3}{2}\right)^2$$

$$= 7\ \text{mm}^2$$

Total Area of Steam

Total Area = Number of teeth x Area
= 10 x 7
= 70 mm2

Force on Cutting Blade

Force required to cut the crop = Shear strength of soyabean steam x Area
= 1.8 x 70
F = 126 N

Fig. 1 Cutting Blade

Calculations of motor:

Electric Motor Torque calculations:

$$T = F \times D,$$

Where,

D = distance at which force applied is 0.018 m = 18 mm

$$= 126 \times 0.018$$

$$T = 2.26 \text{ Nm}$$

Motor Selection:
To design a DC motor based on the given specifications:
Torque (T): 2.26 Nm
Rotational Speed (N): 1440 rpm
Voltage (V): 12 V
Calculate Power Requirement
The formula for power in watts when torque and speed are known is:

$$P = \frac{(2\pi NT)}{60}$$

Where:
P is the power in watts.
N is the speed in rpm.
T is the torque in Nm.
Substitute the given values:

$$P = \frac{(2\pi\times1440\times2.26)}{60}$$

$$= \frac{20447.99}{60}$$

$$= 340.79 \text{ W}$$

Calculate Current Draw
The electrical power provided to the motor is given by:

$$P = V\times I$$

Rearranging for current I:

$$I = \frac{P}{V}$$

$$= \frac{340.79}{12}$$

$$= 28.39 \text{ A}$$

Calculation of Battery:

Calculating Energy Requirements for the Motor
Motor Specifications:
Power (P): 340.79 W
Voltage (V): 12 V
Current (I): 28.39 A

Running Time Assumptions
Assume, the motor to run for about 1 hours continuously. The energy needed is calculated using:

Energy (in watt-hours) = Power x Time Energy

$$= 340.79 \times 1$$

$$= 340.79 \text{ Wh}$$

Battery Design
Since the motor operates at 12 V, design a battery system to provide 12 V and store enough energy.
Battery Capacity Calculation
The capacity of a battery in ampere-hours (Ah) is given by:

$$\text{Capacity (Ah)} = \frac{\text{Energy (Wh)}}{\text{Voltage (V)}}$$

$$= \frac{340.79}{12}$$

$$= 28.39 \text{ Ah}$$

Calculation of Solar Panel:

Solar Panel Design

The solar panel needs to generate enough energy to recharge the battery in a reasonable amount of time that is within 4 hours of sunlight.

Calculating Solar Panel Power

To fully charge a 28.39 Ah battery at 12 V (which stores 340 Wh of energy, since 12 × 28.39 = 340), so need a solar panel system that can deliver at least 110 W to cover charging losses and inefficiencies (assuming around 80% efficiency).

$$\text{Solar Panel Power} = \frac{340\ \text{Wh}}{(4\ \text{hours x } 0.8\ \text{efficiency})}$$

$$= 106.25\ \text{W} \approx 110\ \text{W}$$
$$= 110\ \text{W}$$

Charge Controller Design:

To regulate the energy flow from the solar panel to the battery, use a MPPT charge controller.

Type: An MPPT (Maximum Power Point Tracking) Charge Controller is more efficient and maximizes the energy harvested from the solar panel.

Current Rating:

$$\text{Current Rating} = \text{Solar Panel Power / Battery Voltage}$$
$$= 110 / 12$$
$$= 9.16\ \text{A}$$

Select a 12 V, 9 A MPPT charge controller to handle the current safely.

Design of Scotch Yoke Mechanism

Stroke length = 120 mm

Crank speed = motor speed = 1440 rpm

From the stroke length:

Crank radius (R)

$$R = \frac{L}{2}$$

$$R = \frac{120}{2}$$

$$= 60\ \text{mm}$$

Angular Velocity

$$\omega = \frac{2\pi N}{60}$$

$$\omega = \frac{2\pi \text{ x } 1440}{60}$$

$$= 150.8\ \text{rad/s}$$

Displacement of the Slider

Slider moves from − 60mm to + 60mm (total stroke = 120 mm)

Velocity of the Slider

$$\upsilon max = R \times \omega$$
$$= 60 \times 150.8$$
$$= 9048\ \text{mm/s}$$
$$= 9.05\ \text{m/s}$$

Acceleration of the Slider

$$amax = R \times \omega^2$$
$$= 60 \times (150.8)^2$$
$$= 1368.4\ \text{m/s}^2$$

Fig. 2 Scotch Yoke Mecchanism

Design of Frame and handle:

- Breadth of frame: 800 mm (Cutting Blade length (600 mm) + Clearance assumed (200 mm))
- Length of frame: 800 mm
- Height of handle = The average height of male in India is up to 5ft 5inch that is 1676mm and female is 5ft that is 1524mm. So, we selected the height of handle according to that, which is 864mm. This height of handle is suitable for both male and female according to the ergonomic considerations.
- Length and diameter of handle = The length of handle selected is 165mm based on average size hand which is 188mm for left hand and 181 for right hand. The diameter of handle is selected 20mm for easy holding.

Fig. 3 Frame and Handle

VI. Conclusion

The solar-operated agriculture crop cutter developed in this project provides an effective alternative to traditional fuel-powered harvesting machines. By utilizing solar energy stored in a battery to power a DC motor, the system enables efficient crop cutting while eliminating the need for fossil fuels. Its compact design, ease of operation, and ability to handle multiple crops make it especially useful for small and medium-scale farmers seeking affordable and sustainable solutions.

This project demonstrates the practical application of renewable energy in agriculture, promoting both environmental and economic benefits. The elimination of harmful emissions and the reduction in operating costs highlight the system's potential for broader adoption. With further optimization and scalability, this solar-powered crop cutter could play a significant role in supporting green and efficient farming practices.

Fig. 4 Front View of crop cutter

Fig. 5 Side view of crop cutter

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