

Conceptual Design and Development of Portable Solar Multi Crop Cutter

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ABSTRACT: Agriculture is one of the most important sector of Indian economy since decades. It is the most vital source of employment for majority of human resource in the country. In our country approximately about 60 percent of the total labor force is engaged in agriculture. Solar energy abundantly available from sun can be utilized and resourceful farming can be done by designing the equipment's for agricultural purpose, mainly in India to focus in certain situations such as how to increase the production and revenue, how to reduce the cost and labor. To excel these problems, the work aims to conceptually design, select and develop the machine which runs with the help of solar power which targets the small scale farmers to cut the multi-crops at a time who have land area of less than two acres for farming. The machine is designed for its low cost, rough use and high compatibility. The machine utilizes solar power, which is directed to the rotary blades via solar panel, DC motor and battery arrangement. Thus providing a portable, cost effective, and pollution free machine to farmer.

I. INTRODUCTION

The major source of income for India is through agriculture. Amongst the globe, India being the second largest country in agri output. In spite of ranking the second largest country India faces the major problem is shortage of labor for agriculture, because of this shortage, farmers have adopted mechanical equipment for harvesting, cutting of crops and so on which helped the researcher to widely look into the issue to develop an reliable and effective machine for farming which directly reduce the burden to farmers in several aspects. But the development of new equipment's were majorly concentrated on landlord having more acres of land for farming, which yield more income to farming but neglected the small farmers (less than 2acres) and also use of fossil fuels in the machines lead to pollution in the environment and depletion of ozone layer [1]. "Agriculture and associated segments like forestry, fisheries accounted for 13.7% of the GDP in 2013, about 50% of the workforce". According to World Health Organization, Slow growth in agriculture is an interest for policymakers as 2/3rd of India's population depend upon rural occupation for a living [2]. The problems associated to small scale farmers awakens an idea to design a portable crop cutting machine. Farming industries are exceeding better heights with the developments of latest machines and new techniques of attaining excellent yield has been exposed the concerned business to the competition. Today farmers are conscious about recent developments & machineries which will raise those better yields & help them to achieve it with machineries [3]. Solar energy being abundantly available in nature can be utilized to develop a farming equipment which eases the work of the farmer. In detailing with solar energy every single minute the sun radiates about "5.68×10²⁶ calories" of energy and the earth collects only "2.55×10¹⁸ calories" of energy. The total solar energy that is estimated to be of thirty thousand times more than the total annual energy of the world [4] [14]. Pathak, T. N. et al [5] reviewed on developing on Solar Powered Multi Crop Cutter for Harvesting where we observed the ease of manufacturing, simplification in drive mechanism, ease in harvesting, cost effective and ecofriendly machine was achieved. Similarly Vilas S. Gadhav et al [6] focused on design and developing an electric motor operated multi crop cutter where design of machine was targeted for 2 acre land farming. The success rate was quite high during cutting of crops, which reduced the cost of harvesting. Ritesh R. Jadhav et al [7] worked on design and analyzing the performance of portable solar power-driven crop cutter for paddy application where reduced weight of the model is observed and it does not affect the environment which helped the farmers to have an efficient harvesting machine. Sharath T D et al [8] focused on multipurpose Agriculture machine, where they concluded there was less usage of man power and time which directly influences on the reduction of cost in small scale farming. Manjeet Prem et al [9] studied on crop harvesting machines which informs us about reaper forms

the important aspect in timely harvesting of crops, battery operated reapers are ecofriendly, ease in operation of the machine because of less weight and low operating cost which is easily affordable by farmers for better farming. P.B.Chavan et al [10] designed and developed a manually operated reaper which was efficient, which was 66% effective in farming (survey in sample of land), stops clogging and decreased cutting losses, but not suitable for uneven farm land and power required is also high. N. Dileepan et al [11] developed a semi-automatic crop cutter with usage of hybrid (solar and manual) where in less effort and ease in operation of the machine with less cost is achieved. In order to obtain a sustainable and effective model conceptual design stages provides a better platform to design and develop the machine.

1.1 Strategies employed in product development

Many Organizations face a diversity in circumstances, some call for innovation from scratch & a few involve in rapid defensive response which may include duplicating a competitor’s innovation. To manage such a situations the organization has to recognize the array of strategies that are potential including innovative v/s imitative, offensive v/s defensive, entrepreneurial v/s organizational development.

1.1.1 Proactive Strategy

Proactive development strategy is dynamic development, usually driven by the requirements of specific groups of consumers referred to as target markets. The sort of proactive development strategy depends on the firm, customer and therefore the product's stage within marketing life cycle. The proactive strategy of a firm is built on a R&D effort to technically develop superior products.

1.1.2 Reactive Strategy

A defensive strategy protects the profitability of existing products by countering competitive new products. A derivative strategy which is predicted on quickly copying a new product before its makers are assured of being successful. To select the suitable strategy we must understand the situations that affect the assessment, thus we review the concepts of growth opportunities, the probable protection for innovation, the size of the market, the strength of the competition, and therefore the firms position within the production/distribution system. [12].

Thus from above information and literature survey on many crop cutting machine, we aimed to obtain cost effective, efficient, solar operated crop cutter will be designed and developed for small scale farmers.

II. METHODOLOGY

2.1 Concept Development for Crop Cutter:

Concept development method is the arrangement of steps which are followed to design and commercialize a creation. Fig1 represents a sequence in developing a concept of the model.



Fig 1: Conceptual Development Block diagram for Crop Cutter [13].

III. A FIELD SURVEY CONDUCTED FOR DESIGNING CROP CUTTER

Analysis on variety of crops has been carried out by visiting a few villages near to our region for example Ragi, Rice, Maize (sample crops grown near to our locality) [1].

The following observations were recorded and summarized during the survey,

1. Average Stalk thickness = 0.25-0.5 inches.
2. Average distance amongst each successive crop = 10-11.7 inches.
3. Average height = 32-36 inches.
4. Uneven land used in farming.
5. Ground clearance to be provided for blade during cutting.

IV. CONCEPT GENERATION

A concept generation is an idea that is appropriately developed to assess the physical principles that govern its performance.

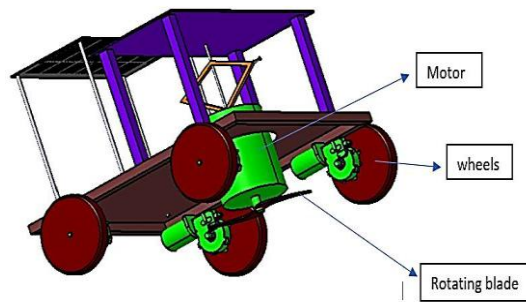


Fig 2: 3Dmodel of the Crop Cutter drafted using AutoCAD (bottom portion view)

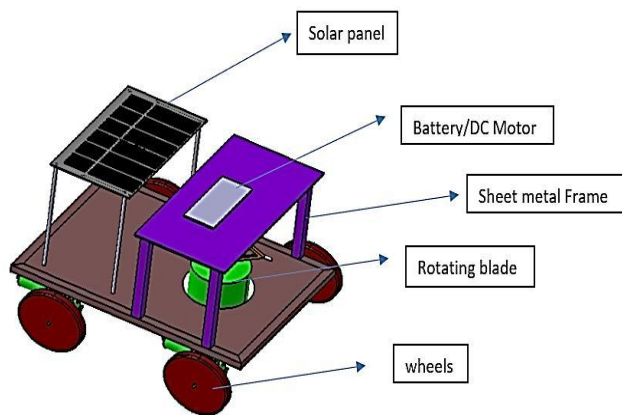


Fig 3: 3Dmodel of the Crop Cutter drafted using AutoCAD (Top portion view)

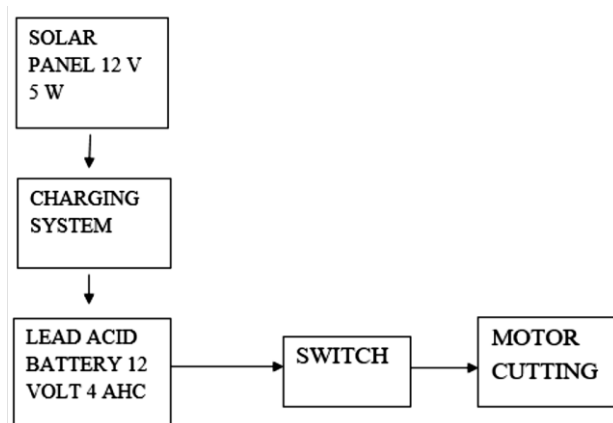


Fig 4: Block Diagram of solar operated crop cutter

4.1 Working Procedure of Solar powered Crop Cutter:

The crop cutter with solar energy contains a base & supporting frame. A DC motor, solar plate, switch, electrical connections, and battery for power storage, wheels and sharp blades, where these components are mounted on to the frame alongside wheels are attached to the frame as shown in Fig 2 and Fig3. The movement of the machine is completely manually i.e. by using human power. The Electricity of the battery is converted to power-driven through a set of blades designed to achieve cutting operation. The electrical circuit ensures power transfer from the battery to run the D.C. motor, in turn the solar plate, recharge the battery which is in operation. The cutting blades take power from the D.C. Motor. When the power switch is on, the electricity from the battery powers the motor which successively actuates the blades. The solar plate generates current to recharge the battery, thereby compensating for the battery

discharge. The rotating blades continuously cut the crop as the mover is propelled forward and therefore cuts the crop. The block diagram of the operation sequence is as shown in Fig 4.

V. DETAIL DESIGN OF THE CUTTER

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.

1. Calculations of blade:

Motor speed, $N = 1250$ rpm, Density, $\rho = 7992$ kg/m³, Breadth of blade, $b = 40$ mm, Length of blade, $l = 450$ mm, Thickness of blade, $t = 1$ mm, Acceleration due to gravity, $g = 9.8$ m/s²

a) Volume = $l * b * t = 1.8 * 10^{-5}$ m³

b) Mass of the blade = Density * Volume = 0.14 kg

c) Weight, $W = mg = 1.4$ N

d) Angular velocity = $\omega = 2\pi N/60 = 62.83$ rad/sec

e) Torque, $T = r * W = 315$ N-mm

f) Power, $P = T * \omega = 19.8$ watt

2. Electric Motor selection:

a) DC motor Speed, $N = 1250$ rpm

b) Voltage, $V = 12$ V

c) Power, $P = 18$ W

3. Motor Torque:

a) Torque, $T = (P * 60) / (2 * 3.14 * N)$
 $= (18 * 60) / (2 * 3.14 * 1250)$
 $= 0.1375$ Nm

i.e. Torque = 137.5 N-mm

b) Shaft material is Mild Steel

Allowable shear stress is 42 MPa

4. Electrical Power Equation:

a) Power $P = I * V$

Where, $V = 12$ V & $P = 18$ W

Then, $I = 18/12 = 1.5$ A

b) In HP = 0.02414 HP

5. Cutter Frame:

The frame will support the shaft assembly with includes a shaft, blades and a gear.

Weight of a blade -5 kg.

Weight of a motor -2 kg

2 battery 12 volt 7 ah -5kg

Frame for hold cutting motor MS -4kg

Thus weight of a total assembly

2 battery + cutter + motor + motor holding frame = $5 + 5 + 2 + 4 = 11.5$ kg

Thus for safer size we will consider weight = 60 kg

6. Solar power calculation:

a) Volt = 12 V

b) Watt = 18 W

c) $W = V * I$

$18 = 12 * I$

$I = 18/12 = 1.5$ A

i.e. $I = 1.5$ A

VI. FABRICATION

The model was fabricated using locally available materials such as DC Motor 12 volt 800 rpm 10 watts, Solar panel of 12v, 5 watts, Rechargeable lead acid battery 12v 7A, MS plate for main frame, Wheels and cutting blades. These components were welded, attached using nut and screw, joined and finished using machining process. Thus obtained a product as shown in the Fig 5.

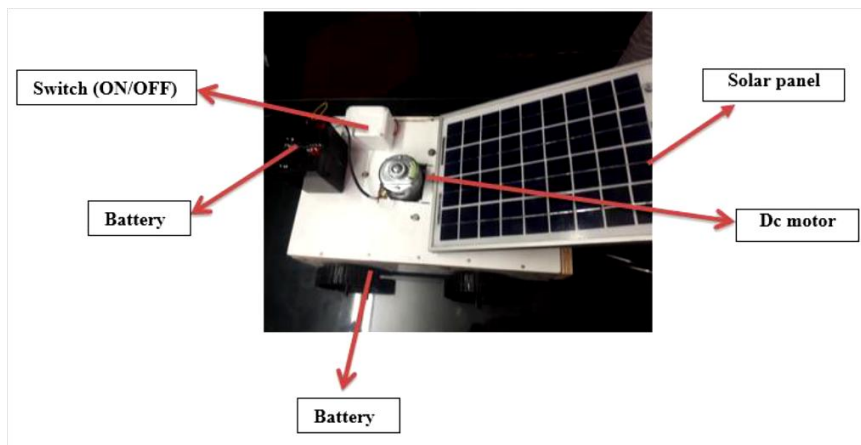


Fig 5: Final fabricated model of Solar powered Multi Crop Cutter

The obtained cutter is simple, portable, effective, requires less time and cost effective to farmers. Machine operation is user friendly, main focus & importance was given for safety in operation.

Advantages:

- ✓ Ease of machine movement.
- ✓ Smaller in size, hence portable.
- ✓ Simple in operation.
- ✓ Non-skilled labor can operate the cutter.

Limitations:

- ✓ Manual movement, can be automated using robotics principle
- ✓ More time require in removal of crops.
- ✓ Operating the cutter in rainy season is difficult.

VII. CONCLUSION

The solar driven multiple crop cutting machine is designed, developed and fabricated accordingly to the requirement for farming, the work was an attempt made to achieve many objective like to obtain efficient crop cutter which is economical to farmer, ecological balance from pollution, use of available resource (solar energy), reduce maintenance cost, and also to overcome the non-availability of labor and huge investment in labor was reduced. The crop cutting time was reduced which increased the productivity and profit to small scale farmers having land less than 2 acres. The work of designing and developing the machine was mainly concentrated on small scale farmers and is successfully achieved.

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