Design and Performance Analysis of Hand-Held Solar Powered Cutter for Paddy

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Abstract: The main objective of this paper carries out a realistic experimental approach of solar power to agriculture. This study considers the design and performance analysis of 12 V, 24W hand held solar powered cutter for paddy. The developed model is performed with two different types of blades in both sunny days and cloudy days. Model operates continuously in cloudy day for 3 hours by using stored energy in battery at 27oc temperature. Time required to full charge the battery is 4 to 5 hours. Finally, the proposed system reduces the weight and also eliminates the harms to the farmers

Keywords — Solar power, Paddy cutter, Performance analysis

I. INTRODUCTION

“Energy - demand” is one the major thread for our country. Finding solutions, to meet the “Energy - demand” is the great challenge for Social Scientist, Engineers, Entrepreneurs and Industrialist of our Country. According to them, Applications of Non-conventional energy is the only alternate solution for conventional energy demand. Now-a-days the Concept and Technology employing this Non-conventional energy becomes very popular for all kinds of development activities. One of the major area, which finds number applications are in Agriculture Sectors. Solar energy plays an important role in drying agriculture products and for irrigation purpose for pumping the well water in remote villages without electricity. This Technology on solar energy can be extended for cutting an agricultural plants are sugar cane, mulberry plants and paddy hence it is a hand-held solar cutter.

India has the largest paddy output in the world and is also the fourth largest exporter of rice in the world. Paddy is cultivated at least twice a year in most parts of India, the two seasons being known as Rabi and Kharif respectively[3].

Presently in India fuel based cutting machines and old harvesting methods are commonly used to cut paddy. Paddy is the staple food for Indian people. Growing of paddy decreases day by day because of shortage of labour and increasing cost of the fuel. Fuel based harvesting cost represents a significant portion of total paddy production cost. Harvesting cost per acre land influenced by many factors including harvesting performance rate per acre, inputs costs like running and labour cost and other operating equipment is used over. Hence there is an urgent need for the solar powered hand held cutter.

II BRIEF INTRODUCTIONS OF DIFFERENT TYPES HARVESTING METHODS

A. Traditional Harvesting Method
Early harvesting methods included, and still do in some fields, the cutting of stalks with machete-type knives, also known as cutlass. This method was very labor-intensive and cutters were subjected to stooping in order to cut the lower length.

B. Mechanical Harvesting Method
Machines are also available for harvesting rice. The machine cuts the paddy stubbles, sugarcane stem and mulberry pruner and lay down in the field. Later, the harvested rice stem should be bundled and stacked in a dry place if not threshed immediately.

III METHODOLOGY

PV system are designed and sized to meet a given load requirement. PV system sizing exercise involves the determination of the size and capacity of various components, like SPV panel, battery, charge controller, DC motor etc. system design also involves a decision on which configuration is to be adopted to meet the load requirement. Once the system configuration is decided the capacity of the various components is decided.
A PV system design and sizing process passes through the following two stages depending upon the level of details used in components sizing:
- Approximate design.
- Precise design.

In the approximate design several simplifying assumptions are made with respect to the component performance, solar radiation data, and seasonal variation in the load of PV panel with season etc. In the precise design, however, attention is given to accurate details of the above factors.

The overall design can be divided into six steps as given below[1]:

Step 1: Determine the PV system configuration.
Step 2: Determine the power and torque required to cutting paddy.
Step 3: Selection of DC motors, by considering the output torque and power input.
Step 4: Determine the size of solar PV module required, the motor rating taking in consideration
Step 5: Selection of storage battery and charge controller circuit.
Step 6: Development of the model.

The functional block diagram is shown in Fig. 1 the main contribution of the work is in designing and developing the charge regulator circuit, selection of motor and fabrication work. Details of fabrication are shown in Fig. 3.

**A. Solar Charge Controller**

The Sunlight is also able to control both the solar panel and battery charging from the solar panel. It attaches directly to lighting fixtures to allow charging. The Sunlight has the ability to control discharging and/or overcharging of the battery. The solar charge controller circuit diagram is shown in Fig. 2 and here is a solar charge controller circuit using IC LM 317. The IC here provides the correct charging voltage for the battery. A battery must be charged with 1/10 its Ah value. This charging circuit is designed based on this fact. The charging current for the battery is controlled by Q1, R1, R4 and Rs. Potentiometer Rs can be used to set the charging current. As the battery gets charged the current through R1 increases. This changes the conduction of Q1. Since collector of Q1 is connected to adjust pin of IC LM 317 the voltage at the output of LM 317 increases. When battery is fully charged charger circuit reduces the charging current and this mode is called trickle charging mode[2].

**B. Fabrication work**

![Fig. 2. Solar Charge Controller Circuit Diagram](image)

![Fig. 3. Details of fabrication work](image)
IV TESTING AND PERFORMANCE ANALYSIS

A. Testing of Rotating Wood Cutting Blade 1

The Various parameters measured with different sizes of paddy bundles using blade 1 and test results are given in table 1.

<table>
<thead>
<tr>
<th>Circumference of paddy bundle (cm)</th>
<th>Voltage (Volts)</th>
<th>Current (Amps)</th>
<th>Time (Sec.)</th>
<th>Speed (rpm)</th>
<th>Power (Watts)</th>
<th>Torque (N-m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>3 cm</td>
<td>11.5</td>
<td>1</td>
<td>2600</td>
<td>11.5</td>
<td>0.04</td>
<td></td>
</tr>
<tr>
<td>6 cm</td>
<td>11.32</td>
<td>1.2</td>
<td>0.4</td>
<td>2300</td>
<td>13.56</td>
<td>0.06</td>
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<tr>
<td>7.5 cm</td>
<td>11.00</td>
<td>1.35</td>
<td>0.8</td>
<td>2000</td>
<td>14.85</td>
<td>0.071</td>
</tr>
<tr>
<td>8.1 cm</td>
<td>10.9</td>
<td>1.38</td>
<td>0.9</td>
<td>1900</td>
<td>15.04</td>
<td>0.08</td>
</tr>
<tr>
<td>9 cm</td>
<td>10.8</td>
<td>1.4</td>
<td>1</td>
<td>1800</td>
<td>15.12</td>
<td>0.081</td>
</tr>
</tbody>
</table>

Time required to cut plant stem is less, motor used here less current, small in size, light in weight, portable and torque is sufficient for cutting agricultural plants. The test results Torque vs Speed and Torque vs Power are shown Fig. 4 and 5 respectively.

Factors required to selection of blade are, number of teeth, blade diameter, teeth length, sharpness.

B. Testing of Rotating Wood Cutting Blade 2

Table 2: Test Results of Wood Cutting Teeth Blade with Sugar Cane Plant

<table>
<thead>
<tr>
<th>Circumference of paddy bundle (cm)</th>
<th>Voltage (Volts)</th>
<th>Current (Amps)</th>
<th>Time (Sec.)</th>
<th>Speed (rpm)</th>
<th>Power (Watts)</th>
<th>Torque (N-m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>3 cm</td>
<td>11.5</td>
<td>1</td>
<td>2600</td>
<td>11.5</td>
<td>0.04</td>
<td></td>
</tr>
<tr>
<td>6 cm</td>
<td>11.23</td>
<td>1.2</td>
<td>1.2</td>
<td>2300</td>
<td>14.56</td>
<td>0.06</td>
</tr>
<tr>
<td>7.5 cm</td>
<td>11.00</td>
<td>1.35</td>
<td>1.4</td>
<td>2100</td>
<td>14.72</td>
<td>0.071</td>
</tr>
<tr>
<td>8.4 cm</td>
<td>10.8</td>
<td>1.38</td>
<td>1.7</td>
<td>1900</td>
<td>14.85</td>
<td>0.08</td>
</tr>
<tr>
<td>9.1 cm</td>
<td>10.7</td>
<td>1.43</td>
<td>1.9</td>
<td>1800</td>
<td>16.05</td>
<td>0.085</td>
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</table>

Torque V/S Speed

Fig. 4. Torque V/S Speed characteristic of solar hand-held cutter

Torque V/S Power

Fig. 6. Torque V/S Speed characteristic of solar hand-held cutter

Fig. 5. Torque V/S Power characteristic of solar hand-held cutter

Fig. 7. Torque V/S Power characteristic of solar hand-held cutter
The test results for blade 2 are shown in table 2. The Torque vs Speed and Torque vs Power are shown Fig. 6 and 7 respectively. The developed solar hand-held powered cutter is performed in both sunny days and cloudy days. Model operates continuous in sunny days and in cloudy day it operates 3 hours by using stored energy in battery at 27°C temperature. Time required to full charge the battery is 4 to 5 hours.

Analysis is limited to only economic analysis between manual harvesting, machine harvesting and solar hand-held powered cutter.

CONCLUSION

The developed model reduces the weight and also eliminates the harms to the farmers. It proves to be an efficient and thus it is a step forward to enrich our rural agricultural sector. The main advantage of this developed protocol is, it does not affect farmer health by any means and also it does not contribute to greenhouse gas emission. By encouraging conservation, increasing the investments in clean and renewable sources of energy, we can build a more secure future for our country. The performance analysis of the solar hand held cutter has done for different plants with various circumferences.

REFERENCE


APPENDIX

<table>
<thead>
<tr>
<th>Component</th>
<th>Specifications</th>
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<tbody>
<tr>
<td>DC Motor</td>
<td>12 V, 2A, 24W</td>
</tr>
<tr>
<td>Solar pannel</td>
<td>12 V (V_mp), 18.7 V (V_oc), 24 W, 2 A (I_mp), 1.24 A (I_sc)</td>
</tr>
<tr>
<td>Charge Controller</td>
<td>12 V, 4A</td>
</tr>
<tr>
<td>Battery</td>
<td>12 V, 7.2 Ah</td>
</tr>
<tr>
<td>Blade</td>
<td>1) 5” x 100Tx1.6mm, 100 teeth</td>
</tr>
<tr>
<td></td>
<td>2) 5” x 40Tx1.8mm, 40 teeth</td>
</tr>
</tbody>
</table>