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DESIGN OF A FULLY AUTOMATED SOLAR GRASS CUTTER FOR CAMPUS CLEANING

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Abstract: Grass cutting is a time- consuming and labor-intensive process. The technology that is available in the present-day for grass cutting operation is mostly the manually handled Diesel operated cutter. These types of equipment operating under non-conventional sources of energy emit green- house gases and pollute the environment and also responsible for climate change. These grass cutters are also a source of noise pollution that adversely affects the health of the cutter and the surrounding people. The cost of diesel is another matter for consideration. To mitigate the problems of the conventional cutter, a solar-powered automatic grass cutter is designed. Solar energy is chosen because it is free of cost, pollution-free and renewable form of energy. The automation is done to reduce the need for labor. The design consists of a solar panel of rated power 20 W, Solar charge controller of voltage 12 V and current 10 A, sealed Lead Acid battery of 7Ah, 24 V high speed DC motor and cutter blades. Various sensors like ultrasonic and temperature sensors and microcontrollers are used for the automatic function of the machine. The paper summarizes all the design parameters, the working principle, design calculations on the basis of the solar radiation data of Guwahati city and also the cost analysis of the designed system.

Index Terms **- Solar Panel; Battery; sensors; cutter blades.**

I. INTRODUCTION

Solar energy is one of the leading renewable energy technologies in India. It is abundant, renewable and most importantly emission free. Many prominent research and development works are going on in the field of solar photovoltaic as well as solar thermal technology. India annually receives 300 days of sunshine with an energy density of 4-6 kwh per square meter. The Government of India has launched numerous schemes under the Ministry of New and Renewable energy (MNRE) targeting 100GW by 2022 [1]. Solar powered grass cutter uses solar energy to power an electric motor which in turn rotates the blades and does the movement of the grass cutter. Unlike the conventional commercial grass cutter which uses gasoline and responsible emission of gases, the solar powered grass cutter is environment friendly and economical [2]. An automatic solar powered grass cutter uses high quality crystalline panels with microcontrollers, ultrasonic sensors, main metallic body, grass cutting blades and a rechargeable battery of capacity 12V. Solar panels are used for charging the batteries. More *et al*. designed a potable and automatic weed cutter device. The automatic device consists of solar panel, a 12 V battery, dc- dc converter, microcontroller 8051 and IR sensor for obstacle detection. Three motors are used in this device, a 12V 300 RPM Motor (for grinding motion), a 12V 3.5RPM Motor (for upward and downward motion of cutter) and 2 12V 60RPM Motor (for forward and backward motion of vehicle). [3] Rizman *et al*. studied about the controller system for grass cutting machine. They have used Radio Frequency for controlling, as it is low cost and effective for long distance transmission. The transmitter is on the remote control, the receiver is places on the lawnmower, and RF signal is transferred via a joystick. The transmitter and receiver is programmed to control the movement of the lawnmower and the speed of blade. [4] Patil *et al*. designed an Arduino controlled automated solar grass cutter. They used 12 V battery and IR sensor for obstacle detection. [5] Mohyuddin *et al*. designed a solar grass cutter whose motors are interfaced to a Schmitt trigger circuit that controls the working of all the motors. The panels are mounted at an angle of 45° to receive the maximum intensity of solar radiation. The solar charger connects the battery when the charge in the battery is low and disconnects the battery when charge is full. Between the motor and the batteries two mechanical circuit breaker is provided. [6] Kubendran *et al*. designed a solar grass cutter that uses an Arduino nano to control all the motors.an ultrasonic sensor is used for object detection. A light dependent resistor is used to detect the boundaries. The rpm of movement motor is 80- 100 rpm and the cutting motor is 1000 rpm. The blades are arranged in antiparallel tangential manner. The charging and discharging time is calculated as four and half hour and two hours approximately respectively. [7] Rahman *et al*. designed a three-wheeler cutting machine of which the front wheel is revolving. Three DC motor with different RPM and gear mechanism is also used. It has been estimated that solar charging rate is 0.03 V/min [8]. Baloch *et al*. studied that the building blocks of automatic lawn mower are sensor and transducer, controller, analyser and actuator. Proximity sensors are capable of sensing the nearby objects without touching it. PIC16F877 micro-controller was chosen to enable the robot to be cost effective [9]. Sivagurunathan *et al*. fabricated one grass cutter with 12V/1.35A rechargeable battery that drives the DC motor with 19,300 rpm. The lawn mower is designed in an ergonomic approach and that is why provide with an adjustable screw. Wood is selected as base material, as it is cheap, easily available and corrosion resistance. Instead of using cutters the cutter uses a string and as it is placed in front of the cutter vehicle so it is useful for cutting in the acute areas. [10]

Ulhe *et al*. designed a solar cutter is a hybrid model i.e. can be charged by both solar and AC. The battery is connected to RF module and the RF module to DC motor. RF module receive signal from controller and supply electricity to the motor. The motors are connected by gearing mechanism. [11] Baingane *et al*. designed a portable solar cutter where Scotch Yoke mechanism is used. They have found that efficiency can be increased by using another mechanism. [12] Deo *et al*. proposed a fully automatic grass cutter where one battery level indicator is used for measurement of battery voltage. Two modes are used for operation – ultrasonic and Bluetooth mood. DPDT relay and DPDT switch are provided for switching the operation. Android phone is used as transmitting device and Bluetooth module placed on it. For obstruction detection, ultrasonic sensor is used. Atmega8 microcontroller is given to interface between Bluetooth and ultrasonic sensor. Drive motor is a high power motor and H- bridge MOSFET is used. [13] Abhraham *et al*. design goal of the robot is to differentiate between the grass and concrete. For inserting input, they have used Keypad in 16*2 matrix. The programing was done in MP Lab and Proteus by using PIC16F877 IC. The hardware setup consists of power supply unit, ZigBee module, voltage regulator, relay, alarm, battery and a PIC16F877 microcontroller. Remote setup, which consists of six sections, which are power supply unit, transformer, battery, keypad, ZigBee, LCD. [14] Ghorade *et al*. fabricated and calculated about one solar grass cutter. They found that with 10 W and 2000-rpm DC motor the torque available is 3.18 Nm. The nearest standard size of MS shaft is 8 mm. The calculated cost of the model is Rs 3170. [15] Hariya *et al*. studied about fully automated solar grass cutter where three motors are used. Two motors are placed on the side and one motor is placed in the front of the device to cut the grass. ATMEGA8 Microcontroller is used for automation. [16] Dilip *et al*. designed solar grass cutter that consists of microcontroller Arduino ATmega328p, IR sensors, LCD Display for better response and understanding to the user. 7.2 V dc motor with integrated gear heads is used. Ultrasonic sensor is placed in front of the robot for maximum detection. [17] Kumar *et al*. studied about automated grass cutting machine using solar energy. Some basic elements of few electronics like LM358 comparator, relay, solar panel, charging circuit, rechargeable battery, temperature sensor, geared DC motor, cutting blades etc. [18]

II. RESEARCH METHODOLOGY

2.1 Design and working of automatic solar grass cutter

The solar grass cutter consists of solar panel, charge controller, battery, DC motor, grass cutter blade. The whole system is placed on top of four wheels and plywood board. The front two wheels are revolving wheel so that the cutter can move according to the needed direction. The solar panel is placed at an angle of 45° due south to get the maximum intensity of solar radiation. The charge controller connects the battery and the panel and protects the battery from overcharging. The DC motor is connected with the battery. The blades are attached with the motor with bolt connection.

One microcontroller with remote is used for automation purpose. The microcontroller is connected with Ultrasonic sensor and temperature sensor. The ultrasonic sensor is used for obstacle detection. Due to continuous using when the temperature of the motor gets increased then the LM35 temperature sensor senses the temperature. When the threshold temperature range is crossed, the microcontroller controls the speed of motor. Different components and their specification used in automated solar grass cutter are shown in Table 1.

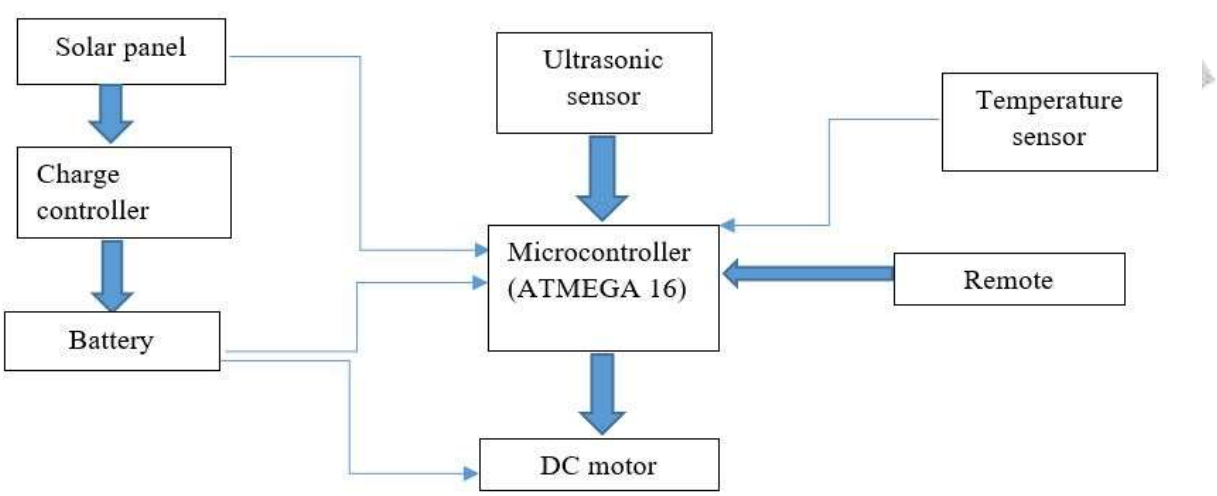

Fig 1: Block diagram of automatic solar grass cutter.

Table 1 Specification of components of the automatic solar cutter:

Sl no	Component name	Specification
1	Solar panel	Rated Power = 20 W (± 3%) V_{OC}= 21.5 V I_{sc} = 1.30 A Dimension = 520×350×22mm Voltage at maximum power Vmp = 17.7 V Current at maximum power I_{mp} = 1.13 A Maximum system voltage = 600 V
2	Solar charge controller	Voltage= 12V Current = 10 A
3	DC battery (sealed Lead – Acid battery)	Voltage = 12 V Ampere hour = 7 Ah
4	High speed DC motor	Rated voltage = 24 V No load speed = 10000 ± 10 % rpm No load current = 1.6 A Rated torque = 400 gcm Operational temperature = 25 -65° C
5	Cutter blade	Extra sharp knife blades

2.2 Basic Model of the Automated Solar grass cutter

The basic model of the grass cutter is designed using Solidworks 16 software. The designed model is shown in Fig 2 and Fig 3.

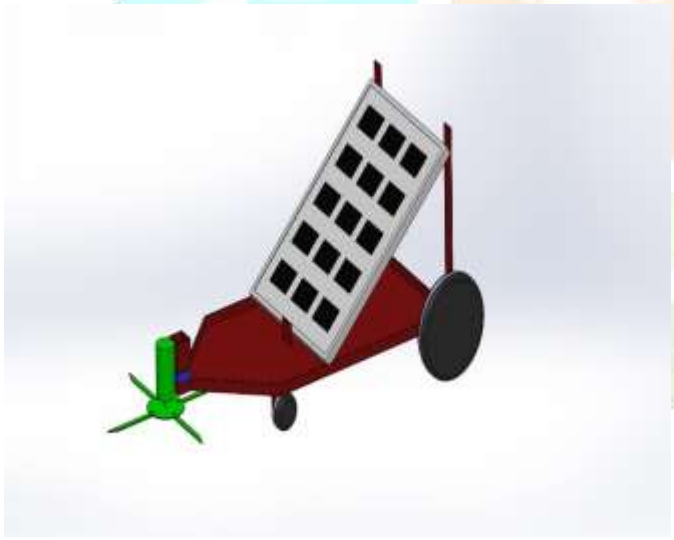

Fig 2 Front view of the grass cutter

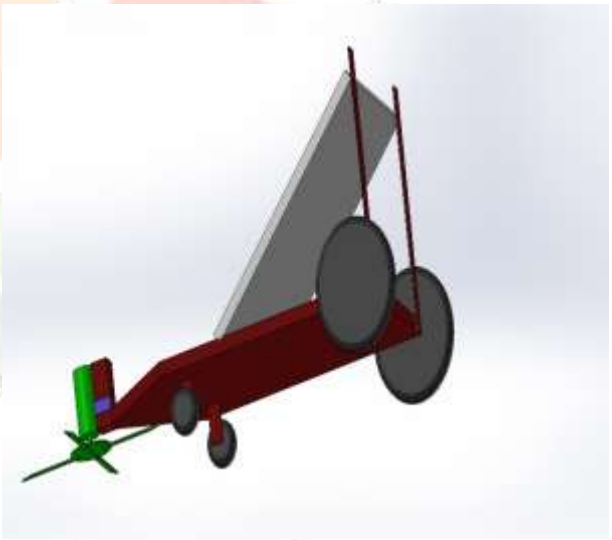

Fig 3. Side view of the grass cutter

III. RESULTS AND DISCUSSION

3.1 Calculations-

- Solar Panel Rated Power = 20 W
- DC Motor Rated Voltage = 24 V, Rated Current = 1.6 A
- DC battery Rated Voltage = 12 V, Ampere hour = 7 Ah
- Assumptions:
  - Solar Panel Efficiency = 18%
  - DC Motor Efficiency = 85%
  - Battery Charging/ Discharging efficiency = 95%
  - Operating hour per day = 1 hr
- DC Motor power = 24×1.6
  = 38.4 W

  DC Motor Output Power supplied to wheel and the blades = 38.4×0.85 W= 32.64 W

  Output Power of the Solar Panel = 20×0.18 W
  = 3.6 W

  Time required to fully charge the battery = (12×7)/3.6 hrs
  = 23 hrs(approx.)

Output Power of the DC Battery supplied to the motor = 0.95×12×7 Wh
= 79.8 Wh

Input Power requirement of the DC Motor per day = 38.4×1 Wh
= 38.4 Wh

Number of days the DC Motor can be operated when the battery is fully charged
= 79.8/ 38.4
= 2.078 days
= 2 days(approx.)

Considering the average sunshine hours of Guwahati city as shown in Fig 4, an estimate is being made for the number of days required to fully charge the battery as shown in Fig 5.

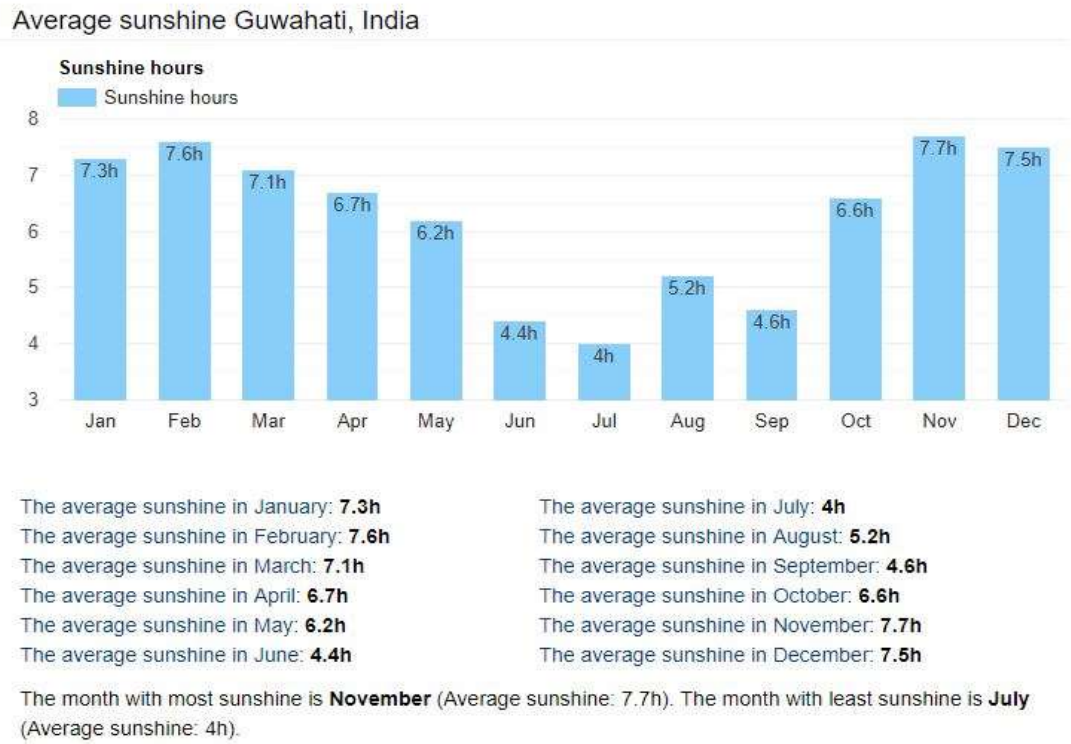

Fig 4: Average sunshine hours of Guwahati city, India

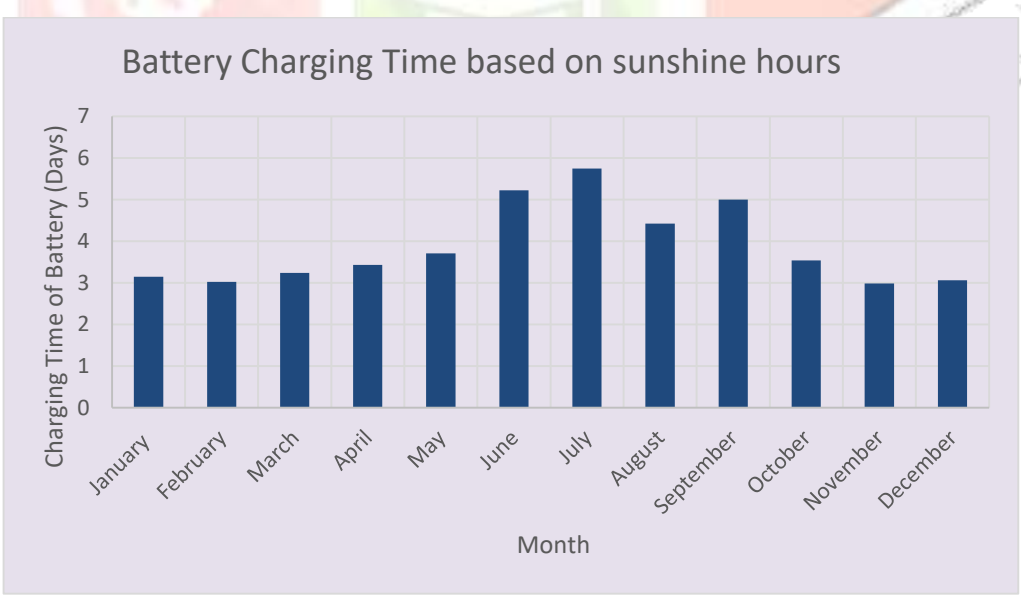

Fig 5: Battery charging time (in days) based on sunshine hours.

3.2 Cost Analysis of different components of the Grass cutter

A cost analysis of the proposed solar grass cutter is performed and the results are represented in Table 2.

Table 2: Cost Analysis

Sl no	Component name	Cost (in rupees)
1.	Solar Panel	1500
2	Solar charge controller	4000
3	DC battery	1000
4	DC motor	600
5	Cutter blade	200
6	Ultrasonic sensor	250
7	ATMega8 Microcontrollers IC	150
8	Temperature sensor lm35 price	300

3.3 Advantages and disadvantages of the automated solar grass cutter

Advantages

- ✓ It uses solar energy, a clean form of energy and hence does not create any air pollution.
- ✓ It has compact size and light in weight, so it can be easily moved from place to place.
- ✓ It produces less noise pollution than the conventional grass cutter which uses gasoline/diesel as its fuel.
- ✓ Wear and Tear is negligible.
- ✓ Operation of the solar powered grass cutter is user friendly so non skilled person can easily operate it.
- ✓ There is no fuel cost as it uses only solar energy.
- ✓ Operation cost is decreased and hence it is economical.

Disadvantages

- ✓ Difficult to operate in rainy seasons.
- ✓ Failure of blade can occur.
- ✓ Time required for removing the grass is higher than the conventional one.
- ✓

IV. CONCLUSION

The solar grass cutter is mainly designed for the campus cleaning in a sustainable and efficient way. Grass cutting is one of the main operation that is carried out in the campus for cleanliness. It is a time consuming and labour intensive process. In addition, it consumes a lot of fuel. The conventional grass cutter that are used in the campus is costly. Therefore, the capital investment and operating cost both is very high. Moreover, one grass cutter is not sufficient campus with large areas such as education institution, playgrounds, garden areas, parks etc. As the cutter burns diesel it creates air pollution to the campus. The noise pollution is also very disturbing for all the residents present in the campus.

To rectify all the problems mentioned above the automated grass cutter that we discussed in the paper may be a good solution. The cutter can be used in both day and night time if properly charged. In rainy season due to less sunshine hours, it will take much time for full charging which is a drawback for the users. The cost of the machine is also very low as compared to the presently used cutters. The fuel i.e. solar energy is free of cost. Therefore, the operation cost is almost negligible in this case. The self-life for the solar panel is almost twenty years. Therefore, the machine will remain intact for many years. Our design implies a pollution free environment to the campus. In the conclusion, we can say that the designed model can be an economic alternative for the users inside as well as for the other users outside the campus.

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