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Development of Grass cutter using Solar Energy

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Abstract: Nowadays renewable energy sources are given more importance because of environmentally friendly and abundantly available in nature. A solar energy source is one of the main contributors to renewable energy sources. The Government of India has taken a major initiative to promote ecologically sustainable growth while addressing India's energy security challenges, by launching the National Solar Mission (NSM) on 11th January in the year 2010 which included some of the schemes such as viz. Solar Park Scheme (for example, Bhadla Solar Park is the world's largest solar park located in Rajasthan; Lohit Solar Park of 20 MW at Tezu, Arunachal Pradesh), Scheme for solarization of Konark Sun Temple and Konark city, Solar-Wind Hybrid Plant with battery storage at Nyoma under Jammu & Kashmir, Green Energy Corridor (GEC) scheme to facilitate Intra-State transmission system between the renewable energy-rich states. A grass cutter is a simple but very useful device required in the maintenance of lawns or the clearance of agricultural fields. In this paper, it is proposed to develop a solar-powered grass cutter along the lines of a traditional lawn mower powered by solar energy. The proposed work is to convert solar energy into electrical energy and stored it in the battery. The motor is run on battery whenever required. Carbon steel blades are attached to the motor shaft to cut the grass. The fabricated model is run for a performance test. The field efficiency of the grass cutter machine is found 84.957% for the rectangular blade (TYPE – 1), 79.95% for S – type blade (TYPE – 2), and 75.135% for the circular blade (TYPE – 3).Index Terms **– Solar grass cutter, rechargeable battery, Solar Panel, renewable energy**

I. INTRODUCTION

Till the 19th century, the scythe, a simple long wooden handle with a curved blade attached to its end, was the only option man had for cutting heaps of grasses to a desirable height, which itself proved to be a very tedious and time consuming task. Today, new technology has brought forward new and improved versions. Researchers in the field of renewable energy are becoming one of the most sustainable solutions economically as well as environmentally for powering the world as well as with an aim to promote clean energy and heal the earth from the dangers of global warming. With the advancements made in emerging PV technologies and the huge amount of energy that we receive from the sun's radiation, solar energy has become one of the most sought after renewable energies. Many researchers have proposed new designs of grass mowers. Mandloi et.al (2010) design and developed a low capital and operational cost shrub cutting machine through field test like determination of torque and force analysis , load and speed test on design specification . Mallick (2009) optimized the operating parameters of a grass trimming machine to produce maximum contribution to the output performance (minimum hand-arm vibration or HAV) followed by engine speed and length of nylon cutting thread. Tuned vibration absorber (TVA) for suppression of HAV in electric grass trimmer was developed by Hao et.al (2011) for reducing the level of vibration. Chouhan (2017) designed a Power Autonomous Solar Powered Lawn Mower system which rendered the mowing task to be independent i.e. self-dependent with regard to carrying out the mowing task. Jabbar (2022) developed solar powered grass cutter for domestic utilizing microcontroller to control the different lawn mower actions. They used two DC gear motors to move the solar grass cutter, and one DC blade to cut the grass quickly. Ismail (2019) introduced developed a Smart Solar Grass Cutter, by using solar irradiance as a primary energy source with the presence of a solar panel to reduce air pollutant and improve the current design for blade position. Chaudhari et.al (2022) designed a smart and automatic solar grass cutter powered by solar energy and electrical supply that has three main systems which were as smart control system, solar system and the grass cutter. In this project, solar energy is used as main power source for development of a portable and compact grass cutter machine.

2. METHODOLOGY

The model has a solar PV panel mounted in such a way that it can receive solar radiation with maximum insolation. The solar panel will convert the sun's radiation into electricity which is achieved by the help of photoelectric effect; hence acting as the primary source of power. This electrical energy is stored in a battery with the help of a solar charger while in operation. The function of a solar charge controller is to increase the current from the panel while the battery is charging for efficient and fast energy storage. It also disconnects the solar panel from the battery when it is fully charged or connects to the panel when the battery charge is low. The system is operated with the help of an electrical switch which helps in connecting the circuit with the direct current (DC) motor to the battery. The DC motor system provides the required torque to drive the rotating cutter blade coupled with the help of a mechanical

coupler to its shaft to shear the grass. This has been achieved by the effective effect of the cutting blade action and the forward movement of the machine. The revolving front and back wheels ensure easy maneuverability of the machine.

Electrical energy of the battery is converted to mechanical energy through a blade that is designed to achieve the requisite cutting operation. The electric circuit ensures power transfer from the battery to run the D.C. motor, whilst the solar panel harnesses the solar energy to continuously recharge the battery thereby compensating for the battery discharge. The cutting blades tap power from the D.C. motor. The electric motor forms the heart of the machine and provides the driving force for the blade. When the power switch is on, the electrical energy from the battery powers the motor which in turn actuates the blade movement. The rotating blades continuously cut the grass as the mower is propelled forward. The block diagram of the grass cutter is displayed in fig-1 and the model is shown in fig.2.

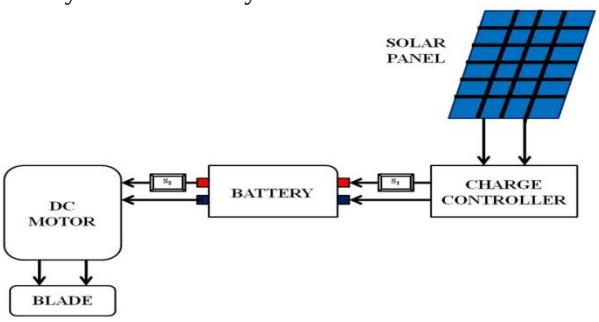

Fig.1: Block diagram of the grass cutter

Fig.2: Model of the grass cutter

2.1 Dimensions of the model

Length of Base = 76.5 cm , Length of base and handle = 129.5 cm, Width of base = 61 cm = 24 inches, Width of base with wheel shaft = 84 cm , Height from ground to handle = 88 cm, Diameter of wheel = 20.2 cm , Ground clearance of the base = 11.6 cm , Length of Solar panel housing = 65.5 cm, Breadth of Solar panel housing = 32.1 cm , Height of Solar panel housing from base to the tip = 63.5 cm , Angle of inclination of Solar panel = 45°,Length of Rechargeable Battery, Solar Charger, DC – DC Boost Converter housing = 35.5cm, Width of Rechargeable Battery, Solar Charger, DC – DC Boost Converter housing = 21.3 cm, Height of Rechargeable Battery, Solar Charger, DC – DC Boost Converter housing = 29.2 cm, Height of G.I. Pipe which holds the D.C. motor = 19 cm, Diameter of G.I. Pipe which holds the D.C. motor = 7.6 cm

2.2 **Justification for the model**: Grass cutting is done effectively using a grass mower reduces the amount of human efforts. Recent innovations from the aspects of energy driven motors indicate the need for a clean energy based mower. It would be economical in both running / operating costs.

2.3. **Cutting blades**: Cutting blades are the primary components of a grass cutter machine for shearing of the grass. They are usually made of tough and malleable metals as they are required to bear the high speed contact with a variety of objects. Also the construction materials that are used vary from manufacturer to manufacturer. Two teeth rectangular blade of size (Length =355.6 mm, Width =30.48 mm, Thickness=1mm, Centre hole diameter =11mm and Two teeth S-type blade of size (Length =355.6 mm, Total width at the centre =30.48 mm, total width at the tip =10mm, Total thickness =1mm, Centre hole diameter =11mm is manufactured from carbon steel materials used as cutter blade. A circular Saw type blade of having dimensions total diameter =180mm, total thickness =1 mm, centre hole diameter=25.4 mm is also used for effective cutting. Carbon steel materials are used due to higher strength, wear resistant, durable and shock resistant.

2.4 **Components**

The various components fabricated in the grass cutter are tabulated below in table-1 with their functions.

Table-1: Components of the grass cutter

Sl. No.	Components	Description	Functions
1	Solar Panel	Brand name - Solar Plaza, 50Watt, Voc=21.6volts, Vmp=18Volts, Imp=2.78A, Isc=2.92 A,12 V	Power supplied to battery
2	Solar Charge Controller	Brand name -Luminous, 6 Ampere; 12 Volts, Dimension-160x120x55mm (LxBxH)	Controlling the charging and discharging
3	Rechargeable Battery	Brand name- Luminous, Voltage -12 Volts; 20 Ampere-hour, Weight-12.9 kg	Power supply to DC motor
4	DC Motor	Brand name- Themisto, RS-775 model; 12 Volts; Weight-350 gm	Rotating the blades
5	Cutter Blade	14'' Carbon steel rectangular shaped blade	Cutting action
6	Wheel	8 inch dia, PVC trolley wheel	Maneuverability
7	Handle	Mild Steel, Square bar (hollow) 2.2 cm (LxB)	To help in pushing the machine forward
8	Main Frame	Mild Steel	Accommodate the whole assembly
9	Shaft	Mild Steel (round)	Provide supports

10	Nuts and Bolts	Mild Steel	Fixation purposes
11	Connecting wires	Copper 1.5mm^2	Connecting different components
12	Coupler	1xSpindle,1x2xWasher, 2xWrench, 1xAllen Key, Total weight-180 gm	Coupling Blade with 5mm dia motor Shaft

3. RESULTS AND DISCUSSION

The machine has been operated when the battery is fully charged and the run-time of the battery up to 60% of its discharge at 8.22 volts was found to be 83 minutes as shown in observation table -2.

Table-2: Observation of change in voltage with respect to the operating time of the battery

Time (in minutes)	0	10	20	30	40	50	60	70	80	83
Voltage (in volts)	13.7	13.27	12.84	12.49	12.02	11.57	10.33	9.25	8.45	8.22

The performance of the machine has been evaluated through field test. A land predominantly covered with perennial ryegrass was mapped out into plots of 10 m x 10 m; three of these plots were selected by randomization process and mowed using three types of blades. The field efficiency of the grass cutter is calculated based on the total area covered by it and the time taken to cover that area. Performance test results are shown in table-3.

Table-3: Performance test results

Performance Test	Results		
	TYPE – 1 (Rectangular)	TYPE – 2 (S – type)	TYPE – 3 (Circular)
Area of grass to be cut (FC_t)	441.399 m^2/hr	441.399 m^2/hr	220.6996 m^2/hr
Desired height of the cut	40 mm	40 mm	40 mm
Time taken	0.2667 hr	0.2833 hr	0.6031 hr
Area of grass cut to desired height (FC_e)	375 m^2/hr	352.94 m^2/hr	165.822 m^2/hr
Field Efficiency (η)	84.957 %	79.95 %	75.135 %
Height of the cut obtained	43 mm	42 mm	40 mm

From the above test results, TYPE – 1 (rectangular blade) blade is found to be the most efficient amongst the three blades but in terms of the desired height of grass cut obtained, it is found that the Circular blades the best amongst the three.

4. CONCLUSION

The solar grass cutter that we have developed has been tested in the field and the results that have been obtained are found to be acceptable. This machine has many advantages like no additional cost of fuel, free from air pollution, lesser mechanical damages as it is being run on solar energy. It can be also operated even without the presence of sunlight as the rechargeable battery can provide power supply for up to 1.383 hours (runtime up to 60 % discharge) after being fully charged. Presently, most of the machines are designed with an aim of eliminating GHG emissions that plays a major cause in climate change. This machine has been developed for the household use and use in other areas such as playgrounds, college campus, gardens, agricultural fields that have lawns. The only disadvantage is that it is not suitable in rainy season.

5. SCOPE FOR FUTURE WORK

The model is manually operated and also can be operated by remote controller. The main frame is made up of cast iron angle bar and sheet of metal, weight about 38.5 kg naked without fixing solar panels and rechargeable battery .So, light weight material such as PVC pipes can be used for the main frame. Any rotating imbalance creates vibration which can be reduced by installing anti vibration components such as anti-vibration bases, anti vibration pads etc. A grass collector can be mounted along with the main frame. Further the handle can be made adjustable such that it can be used by either a short or tall personnel.

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