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Performance evaluation of solar operated bidirectional grass cutter

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Abstract
Power plays a great role wherever man lives and works. The living standard and prosperity of a 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. The best alternative source is solar energy.

The paper aims at fabricating a bidirectional grass cutting machine based upon motor running through solar energy. A solar powered grass cutter is designed and developed, based on the general principle of mowing. To designed solar powered grass cutter A direct current (D.C) motor (3000RPM, 3A,12V), solar panel (12V, 20 watt), a stainless steel blade (2No's) and control switch (2 No's). Mowing is achieved by the D.C motor which provides the required torque needed to drive the stainless steel blade which is directly coupled to the shaft of the D.C motor. The area covered(perimeter) by the blades of cutter is around 1.09m The solar powered grass cutter is operated by two switches on board which are for On/Off and for changing the direction of rotation of blades. The On/Off switch closes the circuit and allows the flow of current to the motor which in turn drive the blade used for mowing. For backup purpose a rechargeable battery (12 volts, 9A) is used so that in case of cloudy weather or in any emergency this can be utilize. The battery recharges through the solar charging controller. Performance evaluation of the developed machine was carried out with different types of grasses.

Keywords: Energy, power, renewable energy, solar energy, grass cutter, solar operated grass cutter and Photovoltaic effect

Introduction
India's energy needs are high and being a developing country the requirements are growing further. Indian power sector is predominantly based on fossil fuels, with about three-fifths of the country's power generation capacity being dependent on vast indigenous reserves of coal. Renewable energy has been an important part of India's energy planning process. To ensure energy security and to reduce the dependence on oil imports, India started to develop and deploy alternative fuels such as hydrogen, bio-fuels and synthetic fuels and to increase clean power (renewable electricity) the technologies that were opted by India are bio, wind, hydro, solar, geothermal and tidal energy technologies Ali Reja Osmani (2014) [1]. The increasing need to use renewable energy as a sustainable energy base was realized by the world in early 1970s with the imposition of an oil embargo by the Arab states within Organization of Petroleum Exporting Countries. Present day pollution is a major issue for whole world. Pollution is manmade and can be seen in own homes. In case Gas or fuel powered grass cutter due to the emission of gases it is responsible for pollution, Grass cutter moving with engine create noise pollution due to the loud engine, and local air pollution due to the combustion in the engine and the cost of fuel is increasing hence it is not efficient. Also, a motor powered engine requires periodic maintenance such as changing the engine oil.

The sun provides sustainable amount of the energy used for various purposes on earth for atmospheric system. Every minute the sun radiates about 5.68×10^{26} calories of energy and the earth intercepts only 2.55×10^{18} calories (NRF, 2010). This represents only 2000 millionth of the total solar energy sent into the space. The total solar energy is estimated to be 30,000 times greater than the total annual energy of the world (Mgbemu, 2005). The solar powered lawnmower is based on the same principle that other early inventions of lawn mowers works on. The difference is just the application of the energy source. It uses the photovoltaic panel to generate the energy needed to power the grass cutter. It is assumed that a grass cutter using solar as the energy source will address a number of issues that the standard internal combustion engine and electric motors grass cutter do not.

A grass cutter with solar energy will be easier to use, it eliminates down time by frequent trips to the gas station for fill-ups and danger associated with gasoline spillage.

Objectives

1. To design and development of solar grass cutter.
2. To evaluate the performance of developed solar grass cutter in the field.

Solar energy

Solar energy is quite simply the energy produced directly by the sun and collected Elsewhere, normally the Earth. The sun creates its energy through a thermonuclear process that converts about 650,000,000 tons of hydrogen to helium every second. The process creates heat and electromagnetic radiation. The heat remains in the sun and is instrumental in maintaining the thermonuclear reaction. The electromagnetic radiation (including visible light, infra-red light, and ultra-violet radiation) streams out into space in all directions

Photovoltaic principles

The photovoltaic effect can be observed in nature in a variety of materials that have shown that the best performance in sunlight is the semiconductors as stated above. When photons from the sun are absorbed in a semiconductor, that create free electrons with higher energies than the created there must be an electric field to induce these higher energy electrons to flow out of the semi-conductor to do useful work. A junction of materials, which have different electrical properties, provides the electric field in most solar cells for the photon interaction in a semiconductor. They are sometimes called photovoltaic cells because they use sunlight ("photo" comes from the Greek word for light) to make electricity (the word "voltaic" is a reference to electricity).

Major components of solar grass cutter

In this chapter discuss with planning for designing and development of Solar Operated Bidirectional Grass Cutter. In this section, the components selection will be discuss. The components that will be included in this project are DC motor, solar panel, battery, switch's and frame.

Overview of the solar grass cutter

The major components include the direct current (D.C) motor (3000RPM, 3A,12V), solar panel(12V, 20 watt), a stainless steel blade(2No's) and control switch(2 No's), circuit board. The circuit board is use to safety of solar panel in case battery is fully charged. In control system Toggle Switch is control to direction of blade, clockwise and anti clockwise. The assembly of solar grass cutter shown in fig.

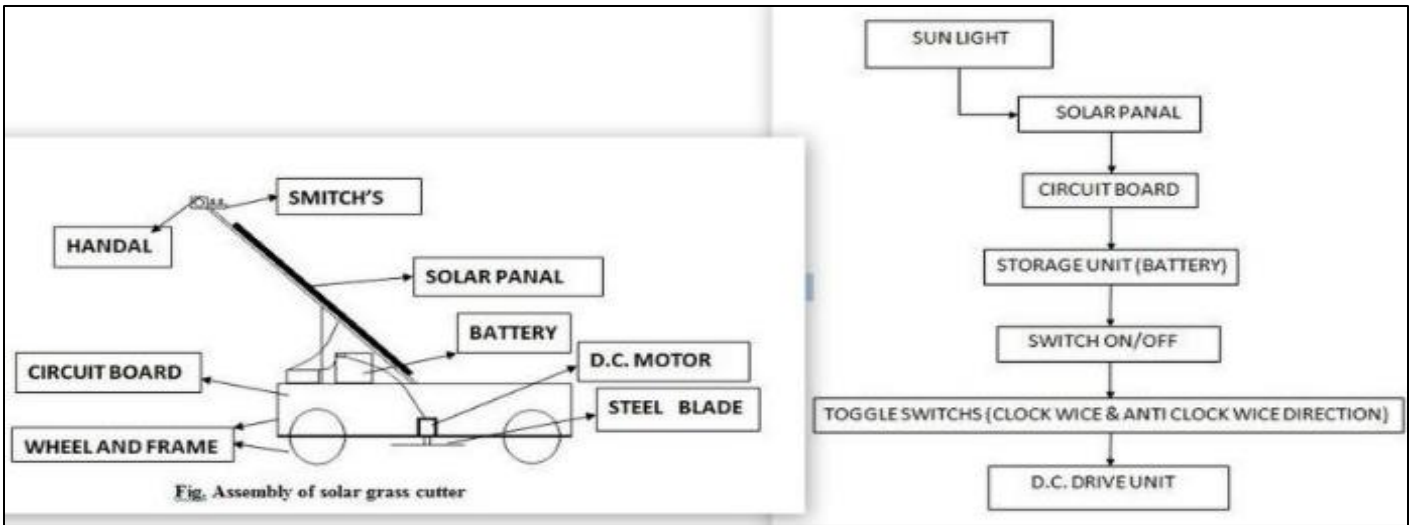

Fig 1: The block diagram of propound system

Working principle of solar grass cutter

The energy conversion is done by solar energy mode. The working principle of solar grass cutter is it has panels mounted in a particular arrangement at frame that it can receive solar radiation with high intensity easily from the sun. The solar panels convert solar energy into electrical energy, using photovoltaic effect and stored in battery. The number of times a battery can be discharge is known as its life cycle.

Electrical energy of the battery is converted to mechanical energy through a set of blades designed to achieve cutting operation. The electric circuit ensures power transfer from the battery to run the D.C. motor, whilst the solar panel power to continuously recharge the battery while in operation. The cutting blades tap power from the D.C. motor. The motor is connected to the batteries through connecting wires between these two switch is provided On/off switch it starts and stop the working of the motor and Toggle Switch is used for direction of blade (clockwise & anti clockwise). The rotating blades continuously cut the grass as the mower is propelled forward and the cut grass. The designed solar powered grass cutter comprises of direct current (D.C.) motor, a rechargeable battery, solar panel, stainless steel blade which is directly coupled to the shaft of the D.C. motor.

Clockwise direction by Toggle switch & Anti clockwise direction by Toggle switch

In toggle switch, if we push backward both livers the direction of motor is clockwise. In toggle switch, if we push forward both livers the direction of motor is anti clockwise. Show in fig.

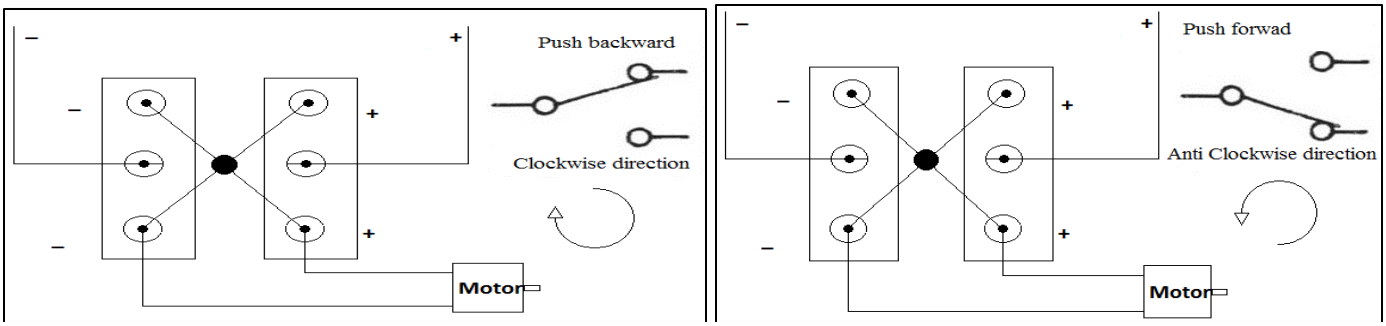

Fig 2: Technical specifications

Table 1: Technical specification of different components

S. No.	Particulars	Specification
1	Solar panel	Dimension: 62*32*2.5 cm Max power, P_{max}: 20 W Vmp (V):18.24
2	Rectifier	Diode: stare connection
3	Battery	Capacity: 12V, 9 Amp Output: 108 w Standby: 12v-12.4v Recharge at: 0.4×5~10 hrs
4	DC motor	Operating voltage: 12 v Operating current: 3 amp RPM: 3000

Fabrication of Solar Grass Cutter

The fabrication has been done according to the reference design and the actual design is done through reverse engineering by taking the measurements of the actual fabricated model. To design the model, in which different parts are designed separately and assembled together makes the actual design.

Frame fabrication & Assembling of the wheels

First we are cut the iron square pipe whose outer diameter and then welded together at an angle of 90° between each other. The length and width of the frame is 1.6 feet and 1.11 feet receptively Fig. Four vertical pipe of each 21 CM are use to maintain distance between two rectangular frame. four wheels are attached to the frame. The diameter of the wheel is 20CM. Take 20 CM long screw and join it to the four side of the frame.

Fig 3: Base frame

Fig 4: Main frame with wheels

Mounting the Motor and Mounting the blade

The D.C. motor is mounted on the base support in cutter frame and it was ensured that it was centered and properly secured. The motor is mounted to plate form the frame with two bolts**.** These blades are fitted by the coupler and bolt. The sharpness of the blade is another important aspect and this will depend on the power and the RPM of the motor used. Here we use two types of blades, S-shape blade and straight blade with length 40cm and width 2.5cm. Thickness of the blade is 0.1mm and its weight is 125g.

Fig 5: Mounting of the Motor

Fig 6: Mounting of the blade

Solar panel mounting and Circuit board and Electrical wiring

Now place the solar panel on the plate form made on the push handle. solar panel to tap the solar energy from the sun and convert it to electric energy that will be stored in the battery. The panel size is 62×32cm, Maximum Power 20W, Maximum Voltage 12V and Maximum Current: 1.25A. A proper electrical wiring is to be put in place putting into consideration the safety of the operator and any other person who may come into contact with the mower. To do this we need to have the correct wire sizing, circuit board and switches put in the right place. In circuit board we use star connection to prevent overcharging when the battery reaches full charge and charging indicator LED which shows that the battery is in charging position.

Fig 7: Circuit board and Electrical wiring

Fig 8: Solar Grass Cutter

Testing

This chapter deals with after completion of the design and fabrication work, different laboratory and field tests were conducted to evaluate the performance of the solar grass cutter and the procedures followed are presented in this chapter.

Performance evaluation of the developed solar grass cutter

Field test

The performance of the machine was evaluated through a field test. A land predominantly covered with Stubborn grass and spare grass was mapped out into plots of 20 mx50 m. three of these plots were selected by randomization process and mowed. The solar grass cutter uses cutting blade arranged in form of a horizontally which is turned by D.C.motor. The act of pushing switch, machine makes the blade revolve.

The theoretical field capacity (FC_t), Effective field capacity (FC_e), and Field efficiency (η) were computed with equations

Theoretical field capacity (FC_t)

Theoretical field capacity FC_t = forward speed x theoretical width

$$FC_t = V_s \times W_t$$

Effective field capacity (FC_e)

$$\text{Effective Field capacity } (FC_e) = \frac{\text{Actual area covered}}{\text{Total time taken}}$$

$$FC_e = \frac{A}{t}$$

Field efficiency (η)

$$\eta = \frac{\text{Effective Field capacity}}{\text{Theoretical field capacity}} \times 100\%$$

$$\eta = \frac{FCt}{FCe} \times 100\%$$

Field capacity

The field capacity was also determined by using

C = Theoretical field capacity× η

Calculation of current and charging time of the battery

Measurement of Current from panel

The current (I) produced by the solar panel and calculated by knowing the maximum power (P) of the solar panel and the voltage rating (V) of the battery that is given by

I=P/V

Determination of Charging time (T)

Charging time was computed by taking the ratio rating of battery in ampere hour (Ah) to the total current consumed by the solar panel.

T= (battery rating in ampere hour)/(total current consumed by the solar panel)

Practical measurement of current and charging time of the battery

Experimentally the current produced by solar panel can be measured by connecting an ammeter in series with supply. The charging time of the battery using solar panel has been measured by continuously charging battery.

Result

In this chapter deals with the analysis, interpretation of result obtained from laboratory and field tests conducted during the studies.

Field capacity

The performance of the solar grass cutter is presented in Table 1, indicating the value of computed effective field capacity

and field efficiency. The average effective field capacity is obtained as 468.62 m^2/hr and Field efficiency (%) as 66%(approx), with operating time of 1 hr. The theoretical field capacity (FC_t) of the machine was calculated to be 700 m^2/hr with average forward speed of 2 km/hr and the theoretical width of .35m. The field capacity of the proposed system is given by the mathematical calculation in appendix A-1. For determination of the actual field capacity its need some necessary to collect some field data which given by the table 2. The machine was seen to be more effective when working in a dry soil condition, because there is proper gripping of the tyres in a dry condition of the soil.

Table 2: Results of effective field capacity (FC_e) & Field Efficiency (%)

Plot No.	Area (m^2)	Time(hr)	FCe (m^2/hr)	Field Efficiency (%)
1	928.22	2	464.11	66.3
2	948.32	2	474.16	67.73
3	935.23	2	467.615	66.8

Time required to cover one hectare land

Time required to cover to one hectare land is inverse proportional to the field capacity and the solar grass cutter cover 468.58 m^2/hr, therefore it will complete one hectare land in 21.34hours.

Calculation of current and charging time of the battery

Current measurement from panel

The solar panel produced current is calculated by the maximum power (P) of the solar panel and the voltage rating (V) of the battery. solar panel with 20 watt and 12 volt voltage the solar panel produces current of 1.6 amp. The calculation is show in the appendix.

Determination of Charging time (T)

The determination of charging time was calculated by taking the ratio rating of battery in amp hr. to the total current consumed by the solar panel. Theoretical the 9amp hour battery takes 5.625 hours to charge fully if the supplied by panel is1.6 amp.

Determination of time taken by battery to discharge completely

The battery rating is 9 Ah, it means it provides continuous 1 Amp current in one hour. But used motor in the solar grass cutter has 3 Amp rating, therefore it will run =9/3=3 hours, if the battery is fully charged.

Conclusion

The solar grass cutter designed, fabricated and tested and the results obtained are satisfactory. This does have engine and the operator is by powered. It will be easier for the people who are going to take the project for the further modifications. This project is more suitable for a common man as it is having much more advantages i.e., no fuel cost, no pollution and no fuel residue, less wear and tear because of less number of moving components and this can be operated by using solar energy.

At present in order to curtail global warming and ozone depletion, the Government of India is offering subsidy for the solar equipments. The industries are producing these components in mass productions, so the cost of the system may come down. So in future it is expected to run all equipments by using solar energy. This system is having facility of charging the batteries while the solar powered grass cutter is in motion. So it is much more suitable for grass cutting also. The same thing can be operated in night time also, as there is a facility to charge these batteries in day light. In the world today, all machines are designed with the aim of reducing or eliminating green house gas emissions which is the major causes of climate change. This solar powered lawn mower will meet the challenge of environmental production and low cost of operation since there is no cost for fueling. A solar powered lawn mower has been developed for the use of residences and establishments that have lawns where tractor driven mowers could not be used.

Future Work

We completed our project successfully with the available sources. But the results and modifications are not up to the expectations. This can be further improved by incorporating the following modifications to obtain better results. The mechanism which we used does not given excepted efficiency. This efficiency can be increased by using some other mechanism. The work can be further improved by making the handle adjustable so that people of different height can easily use this grass cutter. Even the height of the blade can be made adjustable so that the depthe of cutting height can be decided before cutting the grass. In it's advance form it can be made automatic with the help of sensors and advance controllers.

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