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DESIGN AND FABRICATION OF SOLAR POWERED GRASS CUTTER

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ABSTRACT

This research paper presents the design, development, and performance evolution of a solar powered manual grass cutter as a sustainable solution for small scale lawn maintenance. The increasing awareness of environmental concerns and the need for energy-efficient tools in the agricultural sector have led to the exploration of alternative power sources for grass cutting equipment. The proposed grass cutter utilizes solar energy to power its cutting mechanism, reducing dependency on fossil fuels and minimizing carbon emissions. The system incorporates a lightweight and ergonomic design, ensuring ease of use and maneuverability for the operator. The solar panel, integrated into the cutter's handle, captures sunlight and converts it into electrical energy, which is stored in a rechargeable battery for later use. The performance evaluation of the solar-powered grass cutter involved field trials comparing its effectiveness and efficiency with conventional manual grass cutters. Parameters such as cutting capacity, maneuverability, battery life, and overall user satisfaction were assessed. The results demonstrated that the solar-powered grass cutter performed comparably to traditional counterparts while offering the added benefits of sustainability and reduced operating costs. The research findings highlight the potential of solar-powered grass cutters as a viable alternative for environmentally conscious lawn maintenance practices. The system's efficient energy utilization, ease of use, and low maintenance requirements make it a promising option for small-scale applications in residential areas, parks, and gardens. The study provides valuable insights into the integration of renewable energy technologies with manual tools, paving the way for further advancements in sustainable agricultural practices.

Keywords: Solar, Cutter, Grass, Lawn, Energy.

1. INTRODUCTION

Nowadays scarcity of fossil fuels induces the usage and necessity of alternate fuels. So researchers are busy in evaluating the sources, solar powered projects are given more importance; many fields are depended on solar energy now. The sun, an average star, is a fusion reactor that has been burning over 4 billion years. It provides enough energy in one minute to supply the world's energy needs for one year. Solar energy is a form of renewable energy derived from the sun's radiation. It is a clean and abundant source of power that can be harnessed and converted into various forms of usable energy. Solar energy is primarily captured through solar panels, also known as photovoltaic (PV) cells, which are composed of semiconductor materials. When sunlight strikes the solar panels, photons from the sunlight excite the electrons in the semiconductor material, generating a flow of direct current (DC) electricity. This electricity can be used immediately, stored in batteries for later use, or converted into alternating current (AC) electricity using an inverter to power homes, buildings, and electrical appliances. Solar energy offers numerous benefits. First and foremost, it is a sustainable and renewable energy source, as the sun's energy is virtually limitless. It produces no greenhouse gas emissions or air pollutants, contributing to a cleaner and healthier environment. Solar power systems require minimal maintenance and have a long lifespan, making them cost-effective over time. Solar energy is versatile and can be utilized in various applications. It can power residential homes, commercial buildings, and even entire cities. It can also be used to heat water in solar water heaters, provide electricity for outdoor lighting, or support off-grid systems in remote areas where access to conventional electricity is limited. Photovoltaic (PV) cells, commonly known as solar cells, are electronic devices that convert sunlight directly into electricity using the photovoltaic effect. They are a key component of solar panels, which are widely used to harness solar energy for various applications. The manual operated solar grass cutter is a grass cutting robotic vehicle powered by solar energy and pushed by human operator. The model uses solar energy to power grass cutter motor. This project of a solar powered automatic grass cutter will relieve the consumer from moving their own lawns and farm and will reduce both environmental and noise pollution and energy use by implementing solar panels. Ultimately, the farmer will be doing more for the environment while doing less work in their daily lives of farmers. The Solar Grass Cutter is a mechanical device used for cutting grass with the help of solar energy instead of electricity. First of all, its body is made with the help of hollow square bar, then wheel is placed below the body of square bar. Then incline fiber plate is kept on a body, then on incline fiber plate solar panel is kept. Which transmit solar energy & then solar energy is converted into electrical energy & electrical energy is converted in to mechanical energy. This electrical energy is transmitted to electric motor. On the shaft of the electric motor a blade is connected having cutting edge which cut's the grass.

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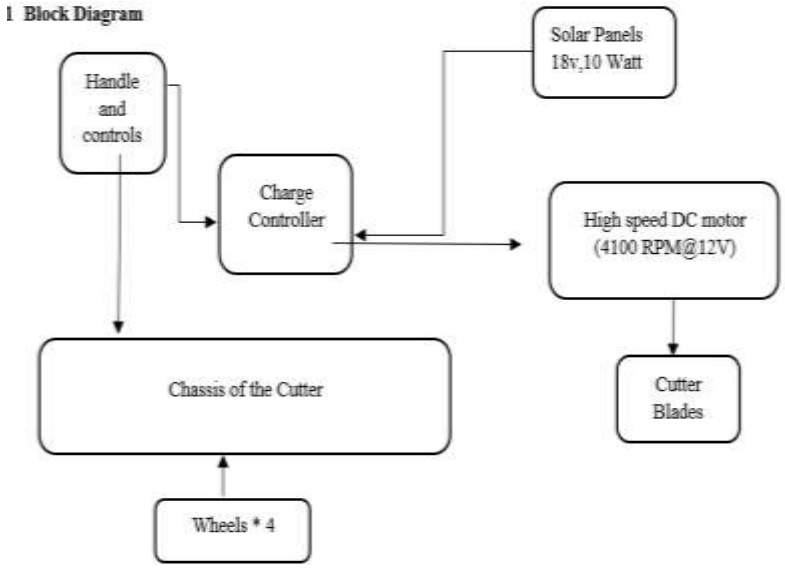
2. METHODOLOGY

The smart grass cutter puts forth a completely semi-automatic grass lawn cutting mechanism. The hand pushed vehicle is equipped with a grass cutter blade that allows for grass cutting at high RPM. Also the system uses a solar panel to demonstrate the charging of vehicle movement battery. Thus this system allows for minimum manual grass cutting system with minimum the need for any human intervention. This hand pushed solar powered grass cutter will have higher speed of grass cutting in farming and gardening works. Operator will just need to run the cutter through the area. The power of cutting will be generated through solar panel installed on board of the vehicle. Controls will be given to operator handle and high speed grass cutting motor is operated. Thus cutting of grass from room is achieved with flexibility to reach each and every corner of a area by using hacksaw cutting blades.

2.1 Block Diagram



3. DESIGN AND ANALYSIS

When designing the Solar-Powered Grass Cutter, several factors were taken into consideration to ensure that the device was efficient, durable, user-friendly, and environmentally sustainable. Some of the key factors that influenced the design of the device are:

Energy Efficiency: The device was designed to be highly energy-efficient, with a focus on minimizing energy consumption and maximizing the amount of solar energy that is harvested and stored in the battery.

Durability and Reliability: The device was designed to be durable and reliable, with high-quality components and materials that can withstand the wear and tear of regular use. The device was also tested extensively to ensure that it can operate consistently and reliably in a variety of environments and weather conditions.

Ease of Use: The device was designed to be easy to use, with intuitive controls and a lightweight, maneuverable frame that makes it easy to navigate around obstacles and uneven terrain. The cutting blades were also designed to be easy to replace and maintain.

Environmental Sustainability: The device was designed with a focus on environmental sustainability, with a goal of reducing the carbon footprint of lawn maintenance. By using renewable energy and eliminating the need for fossil fuels, the device helps to reduce greenhouse gas emissions and promote a more sustainable future.

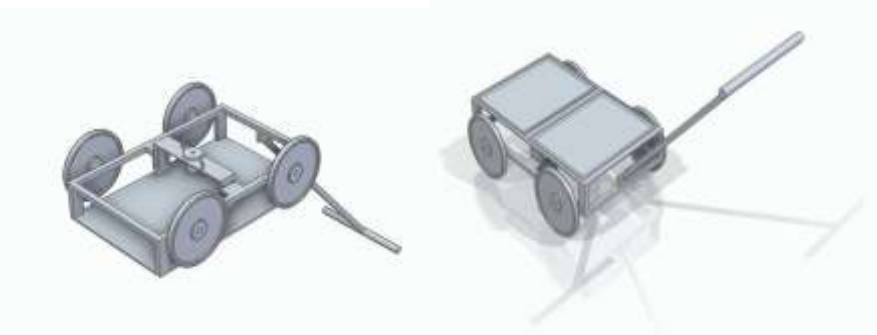


Fig 1. Top view **Fig 2.** Bottom view

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It's important to note that the specific design and features of a manual grass cutter may vary across different brands and models. The outlined features provide a general guideline for a standard manual grass cutter, but it's always advisable to consider individual needs and preferences when selecting a specific model. The dimensions of a manual solar-powered grass cutter can vary depending on factors such as the intended use, user preferences, and the specific design of the device. The dimensions for our grass cutters are:

- Total height = 96 cm
- Ground clearance = 12 cm
- Length of base frame = 60 cm
- Width of base frame = 38 cm
- Height of base frame = 5 cm
- Length of Hacksaw Blade = 20 cm
- Cutting radius of Blade = 10 cm.

3.1 Calculations

- **Design Parameters**

Selection of electric motor:

1. DC Motor speed = 4000 RPM @ No load
2. 3000 RPM @ Cutting load
3. RPM Voltage = 12V

- **Electrical power equation:**

P = I x V

Where I = 8A

V = 12V

∴ P = 8 x 12

= 96W

- **Torque of the motor:**

We know, $P = \frac{2\pi NT}{60}$

Where, P = Power = 96 W

N = Speed of motor = 4000 RPM

T = Torque

$\therefore T = \frac{P*60}{2\pi N}$

$= \frac{96*60}{2\pi*4000}$

= 0.22 N-m = 22 N-cm.

- **Solar panel Calculations:**

Voltage = 18 V

Wattage = 10 W

Also, W = I x V

$\therefore I = \frac{10}{18}$

I = 0.56A= 56 mA.

4. RESULTS AND DISCUSSION

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). 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 combust ion in the engine

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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 5.68×1026 calories of energy and the earth intercepts only 2.55×1018 calories (NRF, 2010).. 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.

4.1 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).

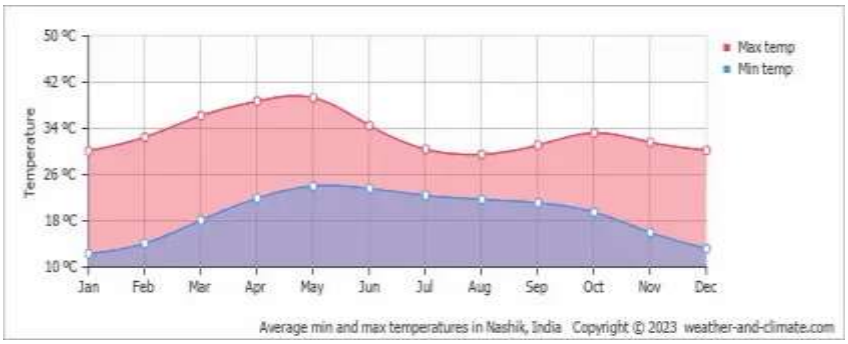

Fig 3. Average temperature in Nashik

As shown in above graph, we can clearly see that the maximum temperature is seen in the month of April and May.Thus these are the perfect months for testing of any solar based model. Also the peak heat hours are in between 11:00AM to 4:00 PM. So it is ideal time to charge the model. Our model usually takes around 4 hours to get fully charged.

$$\text{Battery charging time} = \frac{\text{Battery current capacity}}{\text{Solar Current}}$$
$$= \frac{8\text{Ah}}{2.1\text{A}}$$
$$= 3.8 \text{ Hrs.} \approx 4 \text{ Hrs.}$$

$$\text{Battery discharging time} = \frac{\text{Battery Current capacity}}{\text{Motor Current Capacity}}$$
$$= \frac{8\text{Ah}}{6\text{A}}$$
$$= 1.33 \text{ Hrs.} \approx 1.18 \text{ Hrs.}$$

4.2 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 plot of 20 mx50 m. The Plot was then mowed. The solar grass cutter uses cutting blade arranged in form of a horizontally which is turned by DC motor. The act of pushing switch, machine makes the blade revolve. The theoretical field capacity (FCt), Effective field capacity (FCe), and Cutter efficiency (η) were computed with equations;

Theoretical field capacity (FCt) = operating speed x grass cutter efficiency x Field area

Where, Operating Speed = Approx. 2km/hr. = 0.556 m/s.

$$\text{Grass cutter efficiency} = \left(\frac{\text{Output power}}{\text{Input power}}\right) * 100$$
$$= \left(\frac{12}{18}\right) * 100$$
$$= 66.67\%$$

Field Area = 20 * 50 = 1000 sq.m.

So, FCt = 0.556 * 0.6667 * 1000

= 370.43

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Effective field capacity (FCe)

Effective Field capacity (FCe) = Actual area covered / Total time taken

FCe = A/ t

Where, A = 1000 sq.m

$$t = \frac{\text{Area to be cut}}{\text{cutting speed}}$$

$$= \frac{1000}{0.556}$$

= 1798 seconds or 29.97 mins = 30 mins.

$$\text{So,} \qquad FCe = \frac{1000}{30}$$

= 33.33sqm / min

Grass Cutter Efficiency (η)

η = (Output Power / Input Power) × 100

η = (12 /18) ×100

= 66.67%.

4.3 Performance evaluation

Performance evaluation of a manual solar-powered grass cutter involves assessing its effectiveness and efficiency in cutting grass, taking into account various factors such as field capacity, grass cutter efficiency, and battery performance. The theoretical field capacity of the grass cutter is determined to be 370 square meters per hour, which represents the maximum area it can cover in ideal conditions. However, the effective field capacity, calculated as 33.33 square meters per minute, takes into account real-world factors such as turning, maneuvering, and other operational considerations. This value provides a more realistic estimate of the grass cutter's actual cutting capacity. The grass cutter efficiency is measured at 66.67%. This indicates the proportion of input power that is effectively utilized for cutting grass. Higher efficiency implies a more efficient use of energy, resulting in better cutting performance. The battery charging time is recorded as 4 hours, while the discharging time is 1.33 hours. These values indicate the time required to charge and discharge the battery fully. It is essential to consider the battery performance to ensure uninterrupted operation and to optimize the grass cutter's productivity. The field area of 20 meters by 50 meters specifies the dimensions of the area to be cut. This information is crucial for estimating the time required to complete the cutting operation. By considering these performance metrics, including theoretical and effective field capacity, grass cutter efficiency, battery charging and discharging times, and the field area, one can evaluate the overall performance of the manual solar-powered grass cutter. These factors help assess its capability to efficiently and effectively cut grass, allowing for informed decision-making and improvements in future iterations of the grass cutter design or operational strategies. If it takes 30 minutes to cut grass on a 1000 square meter land, we can calculate the estimated time required for a solar-powered grass cutter to cut 1 hectare of land, which is equivalent to 10,000 square meters. Given that it takes 30 minutes to cut 1000 square meters, we can determine the time required to cut 1 square meter by dividing 30 minutes by 1000, resulting in 0.03 minutes per square meter. To calculate the time required to cut 1 hectare, we multiply the time per square meter (0.03 minutes) by 10,000, which gives us 300 minutes. Converting 300 minutes to hours, we divide by 60, resulting in 5 hours. Therefore, it would take approximately 5 hours for the solar-powered grass cutter to cut 1 hectare of land, assuming a consistent cutting speed and no additional factors that may affect the cutting process. It's important to note that this calculation provides an estimate and may vary based on factors such as terrain, grass density, and the performance of the grass cutter. Additionally, external factors like battery life and the need for recharging can also impact the overall time required to cut 1 hectare of land.

5. CONCLUSION

In conclusion, the manual solar-powered grass cutter offers a sustainable and efficient solution for grass cutting tasks. With its innovative design and utilization of solar energy, it provides several benefits in terms of environmental friendliness, cost-effectiveness, and ease of use. The integration of a solar panel and battery system enables the grass cutter to harness renewable energy, reducing reliance on traditional fuel sources and minimizing carbon emissions. This not only contributes to a cleaner and greener environment but also helps reduce operational costs by eliminating the need for fuel or electricity. The grass cutter's manual operation offers flexibility and control, allowing users to maneuver easily and effectively cut grass in various terrains and conditions. The inclusion of a 10W solar panel and a type 775 motor ensures sufficient power for cutting tasks, while the 26 cm blade width enhances cutting efficiency. The performance evaluation of the manual solar-powered grass cutter highlights its theoretical and effective field capacities, grass cutter efficiency, and battery charging and discharging times. These parameters provide valuable insights into the

cutter's capabilities and help users understand its operational efficiency and productivity. Further advancements in the design of the grass cutter can focus on improving cutting efficiency, ergonomics, and user comfort. Implementing adjustable handle heights, lightweight construction, and ergonomic grips will enhance the overall user experience and reduce operator fatigue. The future scope of the manual solar-powered grass cutter is promising, with potential advancements in battery technology, power management systems, and smart features. Integration of advanced batteries, automation, and smart monitoring systems can further enhance performance, operational efficiency, and maintenance. Overall, the manual solar-powered grass cutter represents a sustainable and effective solution for grass cutting tasks. Its eco-friendly operation, cost-effectiveness, and user-friendly design make it a valuable tool for both residential and commercial applications. As society continues to prioritize environmental sustainability, the manual solar-powered grass cutter emerges as a viable and responsible choice for maintaining lawns and green spaces.

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