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Development of solar power operated grass cutter

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Abstract

The present study focuses on the development and evaluation of a solar-powered grass cutter as an eco-friendly alternative to conventional fuel-based machines. The system utilizes a 40 W solar panel, battery storage, DC motor, and charge controller to operate the cutting mechanism efficiently. The design emphasizes reduced fuel consumption, low maintenance cost, and minimized environmental impact. Experimental analysis was conducted by measuring temperature, voltage, and solar intensity at different time intervals to assess performance. Results indicated that the system performs effectively under varying sunlight conditions, with optimal output observed during peak solar hours. The developed prototype is suitable for agricultural fields, lawns, and institutional areas, offering a sustainable solution for grass cutting. Overall, the solar-powered grass cutter demonstrates significant potential in promoting renewable energy utilization and reducing dependence on fossil fuels.

Keywords: Solar-powered grass cutter, renewable energy, photovoltaic system, DC motor, sustainable agriculture

1. Introduction

Grass cutting is a common task in both agriculture and landscaping, playing a crucial role in maintaining green spaces and farmland. However, traditional methods of cutting grass often rely on manual labor or fossil fuel-powered machines, both of which can have negative environmental impacts and may not be economically sustainable. In response to the increasing demand for eco-friendly and cost-effective alternatives (Duenas *et al.*, 2024) ^[2]. Highlight the availability of affordable grass cutter machines in hardware stores. These machines are commonly used in residential areas with landscaped gardens. The modern designs of these machines are now safer for residential use. Although a variety of grass cutters are available in the market today, particularly from an ergonomic perspective. Certain aspects, such as the blade shape and material, as well as issues related to fuel usage, limited electric movement, and lack of flexibility, still require redesign (Sachin Prabha and Panshetti Sachin, 2016) ^[4].

This proposal introduces a solar-powered grass cutter that incorporates ergonomic design principles, focusing on safety, user-friendliness and cost-effectiveness for farmers.

The key innovation is the use of solar energy, harnessed by a solar panel to replace the petrol-powered systems commonly found in current grass cutter machines. The cost of manufacturing and assembling products is often high, with a significant portion of these costs attributed to the labor-intensive nature of assembly. To address this, the design approach simplifies the product structure, reduces both assembly time and cost, and enables measurable improvements. This report primarily focuses on a specific landscape tool, the solar grass cutter. The solar panel captures sunlight, with light rays causing temperature changes on its surface, thereby creating the optimal conditions for solar energy generation (Sachin Prabha and Panshetti Sachin, 2016) ^[4]. The photovoltaic cells in the solar panel absorb photons and store energy for use.

1.1 Environmental Impact Assessment of Traditional Grass Cutting Methods:

The goal of this research is to advance sustainable agricultural practices and foster technological innovation in grass cutting machinery. According to (Duenas *et al.*, 2024), ^[2] by creating an efficient and eco-friendly solution, we expect to achieve positive outcomes in environmental conservation, economic

sustainability and enhanced agricultural productivity.

1.2 Solar-Powered Agricultural Machinery Opportunities and Challenges

Solar energy offers a promising solution for powering agricultural machinery, providing a renewable and eco-friendly alternative to conventional fossil fuel-powered systems. This study investigates the opportunities and challenges involved in incorporating solar power into farming equipment. By assessing the feasibility, efficiency and potential uses of solar energy in agriculture, the research aims to highlight the contribution of solar-powered machinery to sustainable farming practices (Zhang, Y., Liu, Y., & Li, H., 2021) [7].

The energy captured by the solar panel is transferred through cables to the battery, where it is stored for later use. This stored energy can be accessed when needed. The entire system is regulated by a timer, which controls all activities based on a set schedule. Charge control mechanisms are incorporated to prevent the battery from overcharging, particularly during sunny days. The output from the battery is used to power various equipment as needed. A significant drawback of petrol-powered brush cutters is that they cannot be operated continuously for more than half an hour, and frequent refueling is necessary, making them inconvenient. Additionally, they are not suitable for use in rainy conditions. The main objective of this research is to improve efficiency, eliminate fuel costs, and save time. To address these issues, the proposed solution is the development of a solar-powered grass cutter, with the following specific objective: To develop a manually controlled, solar-powered grass-cutting machine that reduces fossil fuel consumption and pollution while enhancing cutting accuracy and minimizing human effort.

Materials and Methods

In this chapter, various practices followed, identification and procedure to determine the selected electronic components are detailed. The procedure for the selection and evaluations of solar power operated grass cutter was explained. The procedure for analysis to optimize the selected levels of parameters for desired performance and development of the solar power operated grass cutter was detailed. The methods followed for testing of the developed solar operated grass cutter was explained.

2.1 Aim of the Research

Aim is to prevent energy shortages in our country by reducing human labour, operational costs and maintenance expenses. Additionally, a solar-powered grass cutter helps maintain a clean and hygienic community. It is used to remove different types of grasses for various purposes.

2.2 Scope of the Research

The solar panel is connected to the batteries, allowing it to charge them while in operation, ensuring sufficient battery capacity even during cloudy days. This way, the stored energy in the battery can be utilized. A fixed solar panel typically comes with a long-lasting warranty and requires minimal maintenance. In contrast, solar trackers have shorter warranties and require one or more actuators to move the panel.

2.3 Objective

The main objective of this project is the development of a solar-powered grass cutter that operates on solar energy, addressing the limitations of traditional lawn cutters. The objective is to prevent power shortages in India while also reducing manual labour, walking time, and maintenance costs. Additionally, using a solar-powered lawn cutter helps promote environmental sustainability and health. This technology has long been used for managing various types of grass for different purposes. The system is powered by solar energy stored in the batteries, and a solar charge controller ensures proper charging to maintain sufficient power. To protect people, animals and objects, a 30-amp switch is used to operate the motor that drives the blades and brushes.

2.4 Development of a Solar Power Operated Grass Cutter

A prototype of solar power operated grass cutter as an attachment to existing weeder was developed. The prototype of solar power operated grass cutter consists of two handles, cycle wheel, supporting bars between handles, flat supporting bars, tines and leveller. The views of developed solar power operated grass cutter were shown below. The details of the solar grass cutter were shown from Fig. 2.1 to Fig. 2.6. and Plates from 2.1 to 2.4.



Plate 2.1: Tines and blade



Plate 2.2: Cycle wheel

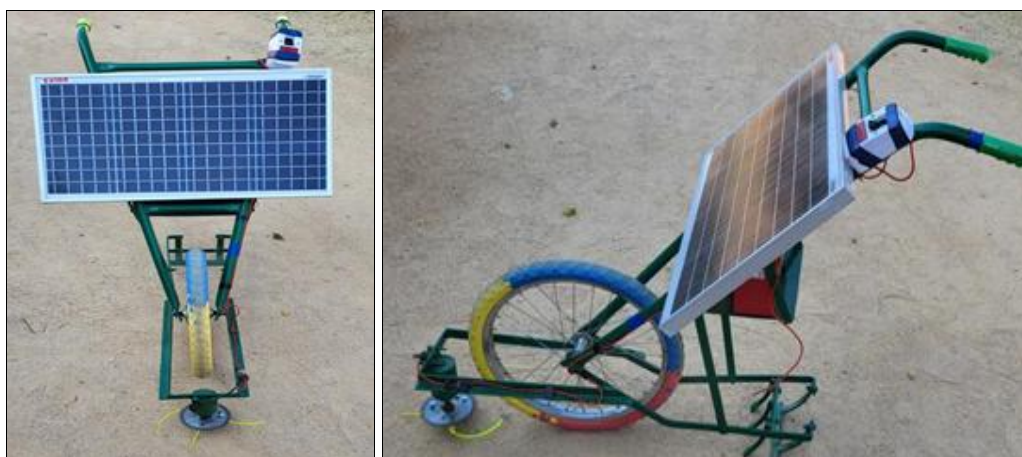


Plate 2.3: Front view of developed solar power operated grass cutter, **Plate 2.4:** Side view of developed solar power operated grass cutter

2.4.1 Methodology Description

The solar power operated grass cutter consists of two supported handles with dimensions of $1200 \times 30 \times 15$ mm (L×W×T), supporting bars between two handles with dimensions of $370 \times 30 \times 15$ mm, $225 \times 30 \times 15$ mm (L×W×T). The two handles were attached to the cycle wheel hub through nut and bolts. The diameter of wheel is 450 mm. Two angle iron bars were welded at the flat supporting bars as well as 140 mm flat bar also welded between the two-angle iron to fix the DC motor. Cutting

wheel was fixed to the DC motor shaft through the nut. GI sheet with dimensions of $27.5 \times 22 \times 0.1$ mm (L×W×T) is also used to place the battery and solar control charger. The rear part of the solar grass cutter was fixed with tines and leveller. After grass cutting, collect and drag the unwanted material upto end of the field. In this research tested with three materials those are cutting wheel and brush cutter nylon wire to determining the better performance. The diagram of research paradigm as shown in below Fig. 2.1.

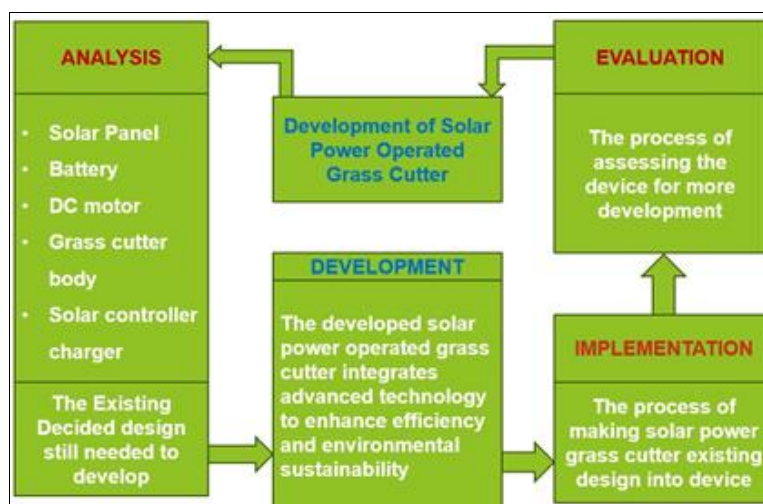


Fig 2.1: Block diagram of research paradigm

2.4.2 Electronic Components and Description

A survey was made to identify the necessary components for fabricating the model. Following this, brainstorming sessions were held to determine the appropriate materials for the model's construction, its design, and how it would operate. Subsequently, the key parts required for the model were sourced from various suppliers. The primary components used in the fabrication of the solar-powered grass cutter are outlined below.

- Solar Panel
- Solar Control Charger
- 12 Volt Battery
- DC Motor
- 30 Amps Switch
- Wire Connections

2.4.2.1 Solar Panel

Introduced a very portable small size, as shown in Fig 2.2. Light weight and more powerful device to give energy small appliance. 40 watt solar panel has advanced encapsulation materials with multi layered sheet of lamination. UTL 40-watt solar PV module is more than 17 per cent efficient with low temperature coefficient, high fill factor and excellent low light irradiance performance. We offer it to our consumers with a long-expected life of 25-30 years. UTL's 40watt solar panel is comes with Polly-crystalline. It is very cost effective and up to 16 per cent of efficiency. UTL solar is now India's most popular solar brand in India that manufactures solar panels. Buy solar panels now and save cost of electricity bills of 25 years.



Fig 2.2: Solar Panel

Table 2.1: Specifications of solar panel

Material	Polycrystalline silicon
Product Dimensions	50L×5W×40H CM
Item weight	4 kg
Efficiency	High Efficiency
Connection type	MC4
Included Panel	Solar Panel 40 watt only
AC adapter current	2.4 Amps
Maximum Voltage	12 Volts
Maximum Power	40 watts
Special Feature	Innovative Cell Technology, PID resistance technology

- **Manufactured by:** Exide Industries Limited
- **Description:** Exide 12V 40Wp Solar PV Module (36 cells)
- **Generic Name:** Solar Photovoltaic Module
- **Type:** EIL40Wp
- High-quality non-breakable glass
- **Year of Manufacture:** 2023.

Low voltage disconnect (LVD) Automatic battery selection USB port for DC load connection luminous Solar Charge controllers are required to fully charge a battery from Solar Panels without permitting overcharge. They prevent reverse current flow at night. Protection against overcharge and reverse current Luminous charge controller charges batteries from solar panels without permitting overcharge and also prevent reverse current flow at night. The solar controller charger as shown in below Fig. 2.3.

2.4.2.2 Solar Controller charger

The solar controller charger 98 per cent efficiency Inbuilt



Fig 2.3: Solar controller charger

2.4.2.2.1 About this item

- Panel supports up to 200 watt @ 12 V and 400 Watt @ 24 V
- Package contains: Pack of 1, 12 V-10 Amp Solar

Charge Controller

- Material: Metal; Color: blue; Inbuilt Low voltage disconnects; 98 per cent efficiency
- Automatic battery selection; USB port for DC load

- connection;
- Charging Current: 10 Amp, Automatic selection of 12 / 24 V Battery
- Durable and long lasting; Elegant and ergonomic
- design; Sturdy and reliable
- Product Dimension - (L × W × H): 40 × 60 × 135 (mm); Weight: 0.3 Kg
- Electronic short circuit protection

Table 2.2: Specifications of solar control charger

Specifications	PARAMETERS
System Rating	6A@12V
Technology	PWM
Maximum Solar Panel Voltage	25V
Low Voltage Disconnect:	
Controlled by Voltage	11.6 ± 0.1 V
Load reconnect	12.6 ± 0.3 V
Boost Voltage For lead acid	14.3V ± 0.2 V
Float Voltage	13.8V ± 0.1V
Self-Consumption	Less than 20Ma
Efficiency a) Charging b) Load	>96 per cent @12V >96 per cent @12V
Operating Temperature Range	0o to + 45
Dimensions (mm)	138 × 57 × 139 × 129 (L × W × H)
Power Connection	30AEuro Terminal Block
Wire Size	2.5mm ²
Grounding	Positive
Net weight	200 gms
Enclosure	ABS Plastic, IP21

2.4.2.3 12 Volt Battery

Exide Xplore 12XL14L-A2 bike battery, the only zero-maintenance VRLA motorcycle battery with the X-Factor. Built with world-class Calcium Effects Technology, it delivers a power-packed performance and endures tough

Indian road conditions. Xplore comes with a 24- month pro-rata warranty that includes a 24-month free replacement warranty. We offer a free installation service at our store. (24 Months Full Replacement + 24 Months Pro Rata) Capacity: 12v. 14AH Battery as shown in below Fig. 2.4.

**Fig. 2.4:** 12 Volt Battery**Table 2.3:** Specifications of 12 Volt battery

Brand	Exide
Battery model	FXLO-12XL14L-A2
Battery series	Xplore
Battery Rating	14AH
Warranty	24 Months
Pro - rated warranty	24 Months
Nominal voltage	12 Volts
Application of usage	Motorcycle
Dimensions L×W×H in mm	135(L)×90(W)×165(H)
Weights in kgs (approx.)	3.4 kgs

2.4.2.3.1 Features of Exide Xplore 12XL14L-A2

- The revolutionary Gas Recombination system eliminates water loss making the battery completely
- maintenance-free.
- The spill-proof design guards against the possibility of leakage, even if mounted in a tilted or inclined position.

- The advanced Lead-Calcium technology leads to low self-discharge.
- The Unique Flame Arrestor ensures greater safety.
- The AGM construction gives superior cranking power and better resistance to vibration and hence makes this battery the most reliable in the market today.
- The permanently sealed VRLA battery comes factory-charged. It needs no refilling, electrolyte, or water.

2.4.2.4 DC Motor

The motor drives the rotation of the blade, enabling it to cut the grass. This device converts electrical energy into mechanical energy. The blade is connected to a DC motor, and once the motor is activated, the blade rotates quickly, allowing it to cut the grass effectively. The 12 Volt DC motor as shown in below Fig. 3.5.



Fig 3.5: 12 Volt DC Motor

2.4.2.4.1 Specifications

- **Speed:** 350-5000 rpm
- **Rated Torque:** 1.1-12.0 in-lbs
- **Output Power:** 01- 21 hp
- **Frame Sizes:** 60, 80, 108 mm
- Brush card or replaceable brushes
- Standard brush life of 2000 + hours

2.4.2.5 30 Amps Switch: PM Cona 32 Amp as shown in below Fig. 3.6 with Indicator ISI Marked DP Switch is a high-performance, heavy-duty double pole switch designed for robust electrical setups. This switch combines exceptional durability with advanced functionality, making it ideal for residential, commercial and industrial applications. Crafted by PM Cona, synonymous with quality and reliability, this DP switch ensures safety, efficiency and long-lasting performance.



Fig 3.6: Cona 32 Amp Switch

2.4.2.5.1 Specifications

- **Rated Current:** 32 A
- **Switch Size:** 1 Module
- **Power/Voltage:** 240 V

- **Brand:** Cona
- **Switch Operation:** Two Way

2.4.2.6 Wire Connections

We have used the wire for giving different connection in motor, battery and solar panel.

2.4.2.7 Size of the DC motor

$$\text{Power (P)} = \frac{2\pi NT}{60}$$

Where;

N = revolution per minute, rpm,

T = Torque Newton -meter

$$\frac{\Delta X \times 3.14 \times 1000 \times \text{Viscosity}}{60}$$

= 23.64 watts of DC motor

2.4.2.8 Size of Solar Panel

1. Load calculation = 23.64 watts of dc motor × 8 per day
= 23.64 × 8
= 189.12 watts

2. For climatic conditions,
Total load = 189.12 watts

3. Considering sunshine = 5 hours

$$\frac{189.12}{5} = 37.82 \text{ watts} \approx 40 \text{ watts}$$

3. Results and discussion

In this chapter, influencing the time interval, voltage and temperature were determined and analysed. The results pertaining to the testing and evaluation of a solar power operated grass cutter with electronic components were investigated for development of grass cutter.

3.1 Prototype analysis

Readings were taken at a specific time interval using a temperature gun, solar power meter, and multimeter.

3.2 Temperature gun

The temperature of the solar panel was measured by using the gun at the panel, and the readings were recorded in Celsius.

3.3 Solar power meter

The device was used to measure sunlight intensity by pointing it towards the sun. A similar process was followed to measure the intensity of the solar panel by directing the device at the panel. The data collected was recorded in W/m².

3.4 Multimeter

It was used to measure the voltage of the solar panel during a specific time interval, with the data recorded in volts.

Table 3.1: Solar Panel Analysis

Time in (hrs)	Temperature in Celsius (°C)	Voltage in Volts (V)	Intensity of Sunlight in (W/m ²)	Intensity of Solar Panel in (W/m ²)
10:00	43	17.90	835	175
10:30	46	18.25	895	190
11:00	48	18.15	940	193
11:30	50	18.05	983	198
12:00	51	17.86	1000	232
12:30	53	17.82	997	241
01:00	55	18.02	1000	231
01:30	58	17.82	995	225
02:00	55	18.21	1000	211
02:30	53	18.61	997	207
03:00	42	18.07	878	193
03:30	39	18.04	780	200
04:00	36	17.32	720	232
04:30	33	17.25	640	238

3.5 Analysis of Temperature and Time

Below mentioned Fig. 3.1 is a graphical representation of Temperature with respect to Time. A Temperature Gun was used to measure the temperature of solar panel at specific time intervals. The provided graph represents the variation of temperature (in Celsius) over time (in hours). The x-axis denotes the time in hours, while the y-axis represents the temperature in degrees Celsius. The plotted data points show the actual temperature recorded at different time intervals, while a linear trend line is also included to indicate the overall trend in temperature variation. Initial Increase in Temperature: The temperature starts at around 45 °C at 10:00 AM and gradually increases with time. It reaches its peak at approximately 1:30 PM, where it is close to 60 °C. Declining Phase: After reaching the peak, the temperature starts to decrease gradually. The decline

becomes more pronounced after 2:30 PM, showing a downward trend. Overall Trend: The linear trend line suggests a slightly increasing temperature trend over the entire duration, despite the drop after the peak. Possible Implications: The data might represent an experiment where heat accumulation and dissipation over time are being analysed. The peak temperature around 1:30 PM suggests an external heat source or environmental conditions influencing the readings. The decline in temperature indicates a cooling effect, possibly due to night conditions or external cooling factors. This analysis provides insight into the temperature fluctuation over time and how it follows a specific pattern. Further interpretation could be made by understanding the context of data collection. Similar results followed by Das *et al.* 2022 ^[1].

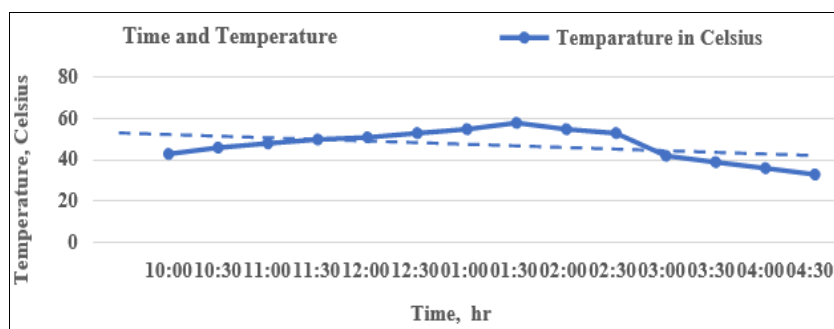


Fig 3.1: Effect of Temperature on Time

3.6 Analysis of Time and Voltage output

Below mentioned Fig. 3.2 is a graphical representation of Voltage with respect to Time. A Multimeter was used to measure the voltage of solar panel at specific time intervals. The x-axis denotes time in hours, ranging from 10:00 AM to 4:30 PM, while the y-axis represents voltage values in volts. The plotted line shows fluctuations in voltage throughout the observed period. The voltage starts at around 17.8V at 10:00 AM and increases to a peak of approximately 18.2V. After reaching the peak, a slight decline is observed, followed by minor fluctuations between 17.8V and 18.2V. Around 3:30 PM, the voltage starts to

drop significantly, reaching approximately 17.2V by 4:30 PM. The voltage trend suggests it may be linked to a solar-powered system where voltage output varies depending on sunlight intensity. The initial increase in voltage could be due to increasing solar radiation in the morning. Midday fluctuations might be attributed to variations in sunlight exposure, shading effects, or load changes. The decline in voltage in the late afternoon is likely due to decreasing solar intensity as the sun sets. This graph can help in understanding the efficiency and performance of a solar power system over the day. Similar results followed by Das *et al.* 2022 ^[1].

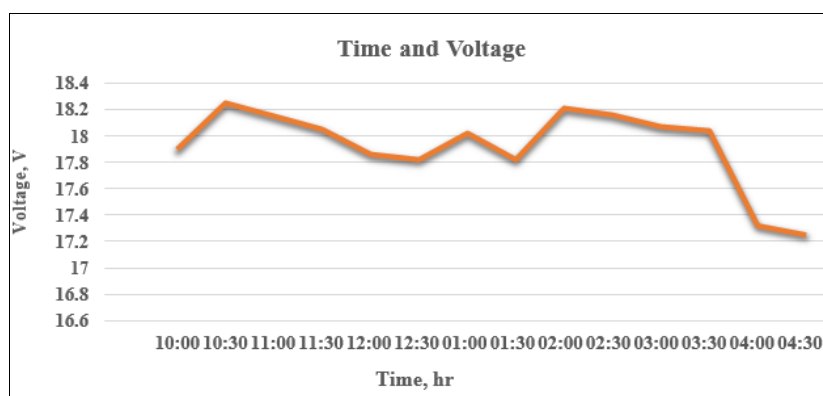


Fig 3.2: Effect of Voltage and Time

3.7 Analysis of the Intensity of Sunlight and Solar Panel Output Graph:

The provided graph illustrates the relationship between the intensity of sunlight (W/m^2) and the intensity of the solar panel output (W/m^2) over a certain period or under varying conditions. The x-axis represents the intensity of sunlight (W/m^2), while the y-axis represents the intensity of the solar panel output (W/m^2). **Initial Sharp Increase:** The intensity of sunlight shows a steep rise initially, reaching around 800 W/m^2 within the first few points. The intensity of the solar panel also rises but at a much slower rate. **Stable Region:** After the initial rise, the sunlight intensity stabilizes at around 1000 W/m^2 for most of the data points. The solar panel intensity remains much lower in comparison, fluctuating slightly but maintaining a nearly steady output. **Decline in Sunlight Intensity:** Towards the later points, sunlight intensity begins to decline after maintaining a peak for some time. The solar panel intensity remains relatively stable despite the decrease in sunlight.

Interpretation and Implications: The solar panel absorbs only a fraction of the incident sunlight, which is expected due to efficiency limitations and energy conversion losses. The sharp rise in sunlight intensity at the beginning suggests a rapid increase in solar radiation in the morning or a shift from a shaded to a sunny environment. The stability in solar panel intensity indicates that solar panels reach a saturation point, beyond which increased sunlight does not significantly enhance their output. The decline in sunlight intensity towards the end may indicate evening time or changing weather conditions (such as cloud cover). This graph effectively demonstrates how solar panel efficiency is influenced by sunlight intensity. While solar energy output increases with sunlight, it plateaus after a certain level, indicating the panel's maximum efficiency. This study can help in optimizing solar panel positioning and usage for maximum energy generation. Similar results followed by Das *et al.* 2022 ^[1].

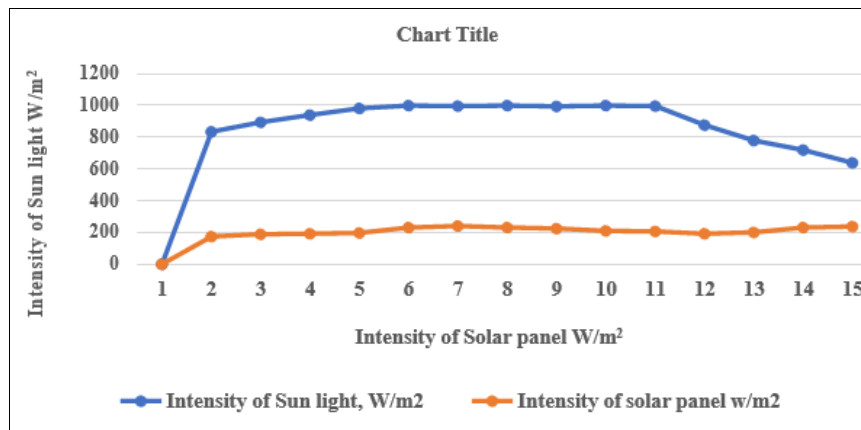


Fig 4.3: Graph between Intensity of sun light and Intensity of solar panel w/m2

Conclusion

Overall, the solar-powered grass cutter represents a promising innovation in the field of sustainable agriculture and landscaping. Continued advancements in solar panel efficiency, battery technology, and automation can further improve its performance and adaptability for various terrains and grass types. A solar-powered grass cutter supports this objective by operating without fuel, making it an economical and environmentally friendly alternative. This type of grass cutter is suitable for residential lawns, institutional campuses and areas that cannot be accessed by tractor-based machinery. Its performance is appropriate for routine grass-cutting tasks and demonstrates strong potential to replace traditional petrol-operated grass cutters.

The concept presented addresses the “Development of a Solar-Power Operated Grass Cutter,” where a solar panel generates the required electrical energy to operate the cutting motor. All necessary hardware components have been integrated into the system with proper planning to ensure smooth and efficient functioning. Additionally, the implementation makes use of advanced integrated circuits and modern technology, contributing to a well-engineered and thoroughly evaluated solution.

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