

## DESIGN OF SOLAR -POWERED GRASS TRIMMER

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### ABSTRACT

Common grass-cutter machines are operated by fuel and electrical energy, which are expensive, and need high maintenance. To keep environment clean and reduce use of fuel a solar powered grass trimmer has been designed in this research work. The purpose of this study is to design and fabricate a solar-powered grass trimmer which is affordable, easy to operate and environment friendly. The grass trimmer uses a 12V, - 100AH battery to power a 12V DC motor of 180W. A solar panel 1 000V system voltage is used to charge the battery. A solar charge controller of 20A is used to control the energy into the battery. The machine uses sheet metal blade to cut the grass. It can run for almost two hours when fully charged and there is no sun. It is easy to tell if the battery is fully charged or flat.

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## 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 [1]. 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 [2]. The natural environment which modern man abide, is usually covered with vegetation which includes forest trees or grass land [3]. Grass cutter machines are operated by fuel and electrical energy which are costly and requires high maintenance [4]. Most of the grass cutter available in today's market is of IC engine type and runs on fuel. This consume about 250 g fuel generally petrol [5]. Use of IC engine cutter release huge amount of carbon in the environment [5]. Pollution is a major issue for whole world. It is manmade and can be seen in own homes [6]. The name solar powered grass cutter provides the information that the usage of solar energy to power an electric motor which in turn actuates the rotor blade and that cut the lawn [7]. Grass cutter machines have become very essential to our daily living in maintaining the yards. Furthermore, environmental awareness on usage of grass cutting machines has caught a great interest among consumers [4]. energy consumption is becoming an increasingly important topic. In today's climate of growing energy needs and increasing environmental concerns, alternatives to the use of non-renewable and polluting fossil fuels must be investigated [8]. One such alternative is solar energy. A solar-powered grass cutter uses sliding blades to cut grass at an even length. Its construction is very simple. It consists of a DC motor, a switch for controlling the motor and a battery for charging it through a solar panel [9]. The first grass cutter developed by Edwin Budding in 1830 in Thrupp [10]. Budding's mower was designed primarily to cut the grass on sports grounds and extensive gardens. His first machine was 480 mm (19 in) wide with a frame made of iron. The mower was pushed from behind [11]. The older method of cutting grass is manually with the use of hand devices such as scissors. This requires more human effort and more time to do the work. The results are uneven. Engine-powered machines increase air pollution and noise and require maintenance [12]. Moving standard motor-powered grass cutters require hard work and are difficult for. Cutting grass cannot be easily accomplished by the elderly and children [13]. The advantage of powering a grass cutter by solar energy rather than by fuel is mainly ecological. With reference to current literature availability, there are different types of grass cutter that are exist in the markets, which may not fulfil the performance and operational cost criteria. The main concentration of this paper is to design and fabricate a solar powered grass cutter which is cost effective, easy to maintain, operated in rural areas, and easy to use. With the help of this portable Solar powered grass cutter, consumers can easily maintain and beautify their yards without any hassle. However, there are few design requirements that must satisfy the study objectives which are:

- To design and fabricate a solar powered grass cutter which is light in weight.
- Which is feasible in size.
- Which is cost effective.
- Which operates in rural areas.

## 2. METHODOLOGY

For the fabrication of a solar powered grass cutter we referred to various literature and papers. Different ideas were gathered and evaluated before designing and fabricating the grass cutter. Several rural areas were visited to find out the challenges in terms of access to electricity and gasoline. Based on these challenges, the idea of designing solar powered grass cutter came about to address this problem. Design and simulation were done by Autodesk Inventor Professional 2016 software which is shown in Figure 1 (a-b). Mathematical analysis was done before finalizing the design. Fabrication was done in Mechanical Engineering workshop at the university of South Africa. Energy from the sun is converted into electrical energy through the solar panel. The energy is stored in a 12V rechargeable battery. Between

the solar panel and the battery, a charge controller regulates the amount of energy going into the battery and cuts off the energy when the battery is fully charged to prevent battery damage. From the battery the energy goes to a 12V DC motor which is connected to the blade. Information was gathered on different component options and evaluated based on the design, easy to maintain, size and cost. Components which met the design requirements were selected and used to fabricate the grass trimmer and are presented in table 1. The machine was tested on different types and lengths of grass in sunny and cloudy conditions.

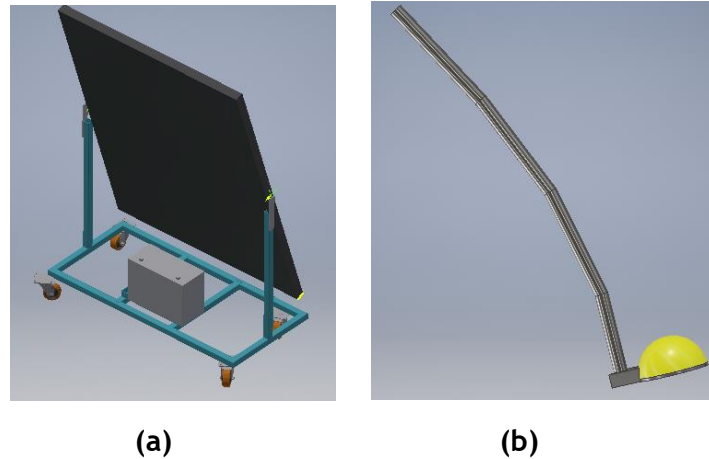


Figure 1: Drawing of Solar Powered Grass Trimmer. (a) movable stand and (b) trimmer frame

## 2.1 Components evaluation

### 2.1.1 Material Selection for the frame and stand

On this study, materials such as aluminium and mild steel were considered in fabrication of the solar powered grass cutter frame and stand. However, mild steel material was selected for both frame and stand since it is cheaper, easy to weld and readily available in the markets.

### 2.1.2 Solar panel

A solar cell, or photovoltaic cell, is an electrical device that converts the energy of light directly into electricity by the photovoltaic effect, which is a physical and chemical phenomenon [2]. Light shining on the solar cell produces both a current and a voltage to generate electric power [2]. Solar panel evaluation based on the four factors is presented in table 2. There are three options considered in this design and evaluated based on the following factors: peak power, peak voltage, peak current and maximum system voltage.

Tale 2: Ealuation of solar panel options

| Factors                    | Option 1: Eggo PV module SA 148 | Option 2: Eggo model SA 150 | Option 3: Solar Frontier KK |
|----------------------------|---------------------------------|-----------------------------|-----------------------------|
| Peak power (W)             | 148                             | 150                         | 165.0                       |
| Peak voltage (V)           | 17.3                            | 17.6                        | 85.5                        |
| Peak current (A)           | 8.56                            | 8.52                        | 1.93                        |
| Maximum system voltage (V) | 715                             |                             | 1 000                       |

### 2.1.3 Solar charge controller

A charge controller or alternatively a charge regulator is basically a voltage and/or current regulator, to keep batteries from overcharging [14]. It regulates the voltage and current

coming from the solar panels and going to the battery[14]. Table 3 present the evaluation criteria used in selecting the suitable solar charging controller. Only two options were considered and evaluated based on the price, warranty and user friendly.

**Table 3: Evaluation of solar charging controller**

| Factors       | Option 1: Firestar solar charge controller 20A | Option 2: RoHS solar charge controller 12/24V auto |
|---------------|--|--|
| Price         | R450   | R529   |
| Warranty      | 1 year   | 1 year   |
| User friendly | Yes  | Yes  |

### 2.1.4 Battery

A battery is used for storing the solar energy which will be converted into electrical energy. Solar cell modules produce electricity only when the sun is shining and do not store energy. It is therefore necessary to store some of the energy produced. The most obvious solution is to use a battery which chemically store electrical energy [15]. Two battery options and the factors used to evaluate this component are presented in table 4.

**Table 4: Evaluation of battery options.**

| Factors      | Option 1: Gamistar solar battery 12V 100AH | Option 2: Allgrand battery 12V 100AH |
|--------------|--|--------------------------------------|
| Price        | R2 800                                     | R2 200                               |
| Warranty     | 2 years                                    | 2 years                              |
| Availability | No stock                                   | Available                            |

### 2.1.5 Motor

This device converts electrical energy into mechanical energy. The conversion is done through the generation of a magnetic field by a means of current flowing into one or more coils. the blade is connected to the DC motor. Evaluation of motor options is presented in table 5. When the motor is switched on, the blades rotate at higher speed and cut the grass.

**Table 5: Evaluation of motor options**

| Factors                 | Option 1: DC motor | Option 2: AC motor |
|-------------------------|--------------------|--------------------|
| Price                   | R2 000             | R1 800             |
| Power inverter required | No                 | Yes                |
| Power inverter size     | -                  | 1 000w             |
| Power inverter price    | -                  | R2 000             |

### 2.1.6 Blade

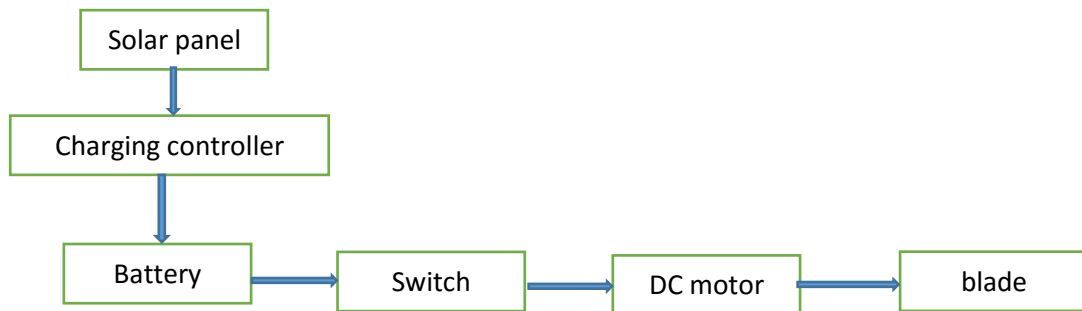
A blade is the part of a tool, weapon or machine with an edge that is designed to cut, stab, slash, chop, slice and thrust, or scrape surfaces or material [15]. Two blades options were evaluated based on easy to replace, long-lasting, availability and presented in table 6. Selected solar powered grass trimmer components after evaluation and a block diagram are presented in table 7 and figure 2 respectively.

**Table 6: Evaluation of blades**

| Factors         | Option 1: wire | Option 2: sheet metal |
|-----------------|----------------|-----------------------|
| Easy to replace | No             | Yes                   |
| Long-lasting    | No             | Yes                   |
| Availability    | No             | Yes                   |

**Table 7: Components of grass trimmer**

| Item                                      | QTY |
|---|-----|
| 12V 100AH battery                         | 1   |
| 1 000W 7.5A solar panel                   | 1   |
| 180W DC motor                             | 1   |
| 12 m x 4 mm cable                         | 1   |
| 20A solar charge controller               | 1   |
| 20A 1 lever double pole industrial switch | 1   |
| 20 mm x 1.5 m round tube                  | 1   |



**Figure 2: Block Diagram of Solar Powered Grass Trimmer**

### 3 FINDINGS AND DISCUSSION

The department in which this project was conducted already had three different types of solar panels. Therefore, there was no need to buy or look for another solar panel. Of the three options presented in table 2, Frontier KK solar panel of a maximum system voltage of 1 000V, 1.93A and a maximum load of 2 400 pa was suitable for this design. From the options presented in table 3, Firestar solar charge controller of 20A found to be affordable, portable and easy to mount. Allgrand GEL-VRLA-battery of 6-CNFJ-100 was the best battery to be used because of its price and availability based on the evaluation in table 4. DC motor was the best option for this project based on the price and complexity of the design. The DC motor takes current straight from the battery, whereas the AC motor needs a power inverter to convert DC current to AC current to run the motor. The total price of the DC motor was R2 000, whereas the total cost of the AC motor was R3 800 because it included the price of the inverter. Based on the options in table 6, sheet metal blade is easy to connect or replace. It also lasts longer compared to wire blade. Wire blade needs another part to hold, which will make more complicated to replace the blade and more expensive. Sheet metal can be found everywhere, whereas grass cutter wire can be found in hardware stores or garden equipment shops. The complete design and fabrication of solar powered grass trimmer is presented in figure 3.



**Figure 3: Solar-powered grass trimmer**

#### 4 CONCLUSIONS

The design and fabrication of a solar-powered grass trimmer that is environmentally friendly, produces less noise and affordable was achieved. The trimmer works up to 10 m away from the charging station, it is 1.5 m long and weighs about 6 kg. The charging station is movable and can be pulled to any place and distance. The sheet metal blade is easy to connect to the motor shaft by just fastening it to the motor shaft by a nut and the washer. The machine can be used to cut different types of grass and it can be used even on a cloudy day until the battery is flat. The battery lasts for almost two hours when it is fully charged if there is no sun on that day. The solar charge controller controls the amount of energy going into the battery. When the battery is fully charged, it cuts off and when the battery is flat, it switches on. This prevents damage to the battery by overcharging it. The machine can be used even in places such rural and poor areas and roadsides where there is no electricity.

#### 5 ACKNOWLEDGEMENT

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