

# DESIGN AND CONSTRUCTION OF A SOLAR-POWERED LAWN MOWER

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## ABSTRACT

Lawnmowers are often powered by fossil fuel or electrical means. Fossil fuel power mowers constitute air pollution in human environment. Electric lawnmowers are uneasy to deal with due to their power source. It is important to construct a lawnmower which will be power by solar power. A solar powered lawn-mower was designed, fabricated and tested at the Faculty of Engineering and Technology, Igboora. The cutting efficiency on Stubborn and Soft grass was found to be 81.0% and 89.5% respectively. This machine tends to proffer solution to environmental pollution caused by lawn mowers powered by Internal Combustion engines and also, it can be easily carried around to mow any form of grasses. This machine is found to be suitable for Nigerian environment where there is epileptic supply of electricity which may hinder effective mow of bushy environments and it was estimated to cost approximately Two hundred and Fifty Thousand Naira only.

**Keywords:** Lawn, Electricity, Mower, Solar, Machine.

## INTRODUCTION

Landscape is an essential element in human environment (Filtrynadia *et. al.*, 2014). Gause *et al.* (2007) suggested that landscape can be used as a tool for community sustainability as well as environment balancing. Lawn, having both aesthetic and recreational values is often used as landscape element in urban areas. Examples; in private, parks and garden (Ignatieva, 2011). Lawn does not only beautify its environment, the quality of soil on which it is nurtured is preserved and can be used later for both agricultural and non-agricultural purposes. It comprise of herbaceous plants, therefore it enhances the ecosystem and regulate the climatic condition of area(s) present. However, the benefits of lawns can be only attained if cultivated and nurtured properly. Lawns

are found to survive in varieties of conditions and thus, it is necessary to curtail its growth to enhance and preserve its aesthetic feature in an environment (Basil, 2013). Lawn mower is a machine which uses revolving blade(s) to trim lawn to an even height as a mean of preserve its quality (Ahmad, 2008). Over the years, many individuals have included modification to the original designed mower, each were to suit a particular need or convenience. Lawnmower blades formerly were powered manually by pushing to turn it (Omoniyi, 2010), as result of intellectual evolvement of man, use of internal combustion engines to power mower blades was introduced (Basil, 2013). The internal combustion (IC) engines were to convert chemical energy (fossil fuel) into mechanical energy which turn the blades. Therefore lawnmower are named after the type of fuel used. Notwithstanding, while IC engines produce mechanical energy, they also release dangerous gases in exhaust which is hazardous to man's health.

Nevertheless, they are noise pollutant (Manpreet *et. al.*, 2016). Lawn mowers powered by internal combustion (IC) engine are also contributors to the presence of gases (release gases such as) Greenhouse gases of the area covered (esp. CO<sub>2</sub>) to the environment. Voluminous presences of greenhouse gases cause increase in temperature present in the environment. Furthermore, uncontrolled air pollution can cause natural disaster such as acid rain, likewise depletion of ozone present above the atmosphere (stratosphere) which protects life from harmful ultraviolet rays from the sun. Noise pollution which is a class of air pollution (Sound) make fossil fuel powered lawnmower be unfriendly to human environment. They produce sound up to 105dB which is above the recommended maximum quality of sound for man (80dB) (Rabinowitz *et. al.*, 2000; Goines and Hagler, 2007).

NYSDEC (2012), suggested that lawnmowers must be designed to reduce pollutions generated than at present. Although, electric mowers cause less pollution to the environment; no gas is emitted to the atmosphere and the noise produced (75dB) (Clean Air Yard Care, 2018) is lesser to those produced by fossil fuel powered lawn mowers. Yet, these mowers create problems such as limited area coverage during operation and possibility of electric shock if cord is not properly inspected (corded electric powered mower). Despite, batteries were introduced to these mowers, problem of charging the batteries reduce the potential of using these mowers for mowing in countries (like Nigeria) experiencing instability of power supply. Energy is often feed into battery through electric power generating plant that uses fossil fuel. Therefore, the major aim of NYSDEC (2012) is not achieved in this process. This aim can be achieved only if the system for charging batteries is a non-pollutive electricity generator.

Tanimola *et al.*, (2014) expressed solar powered lawn mower as the application of solar energy to power an electric motor which in turn rotates a blade that does the mowing. Since solar energy is in abundant (NRF, 2010). As a fact, solar energy is a renewable source of energy obtained from sun radiation. It is environmentally friendly and cheaper in terms of maintenance. Olawale *et al*, 2019 designed and constructed an inverter powered lawn mower whose battery is charged using an alternator which generates a continuous energy which is required to charge the battery. The previous technologies were still unable to cater for a lawn mower which has a free mobility over a long distance and a system with a long-time battery charging using the solar energy, it is therefore necessary to develop a mower which will cater for this lapses.

## **MATERIAL AND METHOD**

Consideration was given to design a solar powered lawn mower that uses a stainless-steel material for the blade because of the strength and durability of the material.

## Power selection

For every lawn mower to mow grass, it is necessary it has a blade. The shear force required to cut annual and perennial lawns is between 9.2N ~ 11.51N. Therefore, the average shear force to mow lawns equals 10.355N. Tanimola *et al.*, (2014), buttressed this and suggested that "a shear force greater than 10N should be used on lawns for effective mow".

Therefore;

$$\text{Dimension of blade} = 400\text{mm} \times 50\text{mm} \times 5\text{mm}$$

$$\text{Area of blade} = \text{length of blade} \times \text{breadth of blade}$$

$$= 0.40 \times 0.05 = 0.02\text{m}^2$$

$$\text{Volume of blade} = \text{Area of blade} \times \text{thickness}$$

$$= 0.40 \times 0.05 \times 0.005 = 0.0001\text{m}^3$$

Since the selected blade was a stainless steel and density of steel equals 7922Kg/m<sup>3</sup> (sign 2005);

$$\text{Mass of blade} = \text{density} \times \text{volume}$$

$$= 7922 \times 0.0001 = 0.7922\text{kg}$$

$$\text{Force} = \text{mass} \times \text{acceleration}$$

$$= 0.7922 \times 9.81 = 7.772\text{N}$$

### *Torque required to turn the blade*

$$= \text{Force} \times \text{radius of blade}$$

$$= 7.772 \times 0.20 = 1.554\text{Nm}$$

*Minimum power required to move the blade in 1 second is approximately; 1.6Watts (1Nm = 1W)*

## Electric motor

The greater the power the greater the efficiency. (Tanimola et. al, 2014), hence, convey power required to move the blade, the strength and density of grain as well as efficiency and factor of safety, 750W (1hp motor), 1400rpm was selected. It would be able to handle different type of grass at expected high efficiency.

## Battery

Available 12V, 200Ah (deep cycle) battery was selected for greater efficiency.

$$\text{Design power} = \frac{\text{Current} \times \text{Voltage}}{\text{power factor}} \quad (\text{Khurimi and Cupth, 2000}).$$

$$\text{Current} = \frac{\text{Power} \times \text{P.f}}{\text{Voltage}} = \frac{750 \times 0.8}{12} = 50\text{A}$$

*The battery is expected to discharge after;*

$$= \frac{200}{50\text{A}} \text{ hours} = 4\text{hrs}$$

## Solar panel

Although, the required power to charge the chosen battery full in 5hrs sunshine;

$$\begin{aligned} &= \frac{\text{Load + energy losses}}{\text{sunshine hours}} \\ &= \frac{750 + (25\% \text{ of } 750)\text{Watt}}{5\text{hrs}} = 187.5\text{W} \end{aligned}$$

A solar panel 250W was selected for effective charging.

## Inverter sizing

Since the load is 750W (electric motor)

$$\begin{aligned} \text{Inverter sizing} &= 30\% \text{ of } 750\text{W} + 750\text{W} \\ &= (225 + 750) \text{ W} \\ &= 975\text{W} \end{aligned}$$

*A 1KVA inverter was selected*

## Charge controller

Since the PV array 200W,

$$\begin{aligned} \text{Charge controller} &= \text{PV array size/ Battery Current} \\ &= 200/50 = 4\text{A} \end{aligned}$$

For efficiency and effectiveness due to cold temperatures 25% of the result was added to it.

$$\begin{aligned} &= 1.25\text{A} + 4\text{A} \\ &= 5.25\text{A} \end{aligned}$$

Therefore, a 10A charge controller was selected.

## Frame development

### Desk

The desk on which the major components were mounted was developed based on the dimension of the components and arrangement.

$$\begin{aligned} \text{Desk length} &= 700\text{mm}, & \text{breadth} &= 500\text{mm} \\ \text{Area of desk} &= 700\text{mm} \times 500\text{mm} \\ &= 350000\text{mm}^2 \text{ or } 3.5\text{m}^2 \end{aligned}$$

### Handle

A handle of 700mm long and 500mm wide was attached to the desk at angle  $60^{\circ}$ . It will help to push the lawnmower easily. It also supports the solar panel frame.

## RESULTS AND DISCUSSIONS

A 2-level adjustment switch was placed at the right hand side of the handle to power ON the inverter that supplies power to the electric motor, the switch is used to select the desired speed of the motor based on the type of grass to be cut. The battery is connected directly to the inverter and the electric motor derives the AC from the inverter which in turn drives the blade. The motor starts to work and its speed is accelerated at or above the speed at which the pulley is driven (about 2800rpm).

The torque from the prime mover is transmitted to the rotary blade via the motor pulley and causes the blade to spin which in turn gives the required mowing process when it comes into contact with the grasses on the lawn. The machine is set into motion by human, pushing with the aid of the handle over all the space covered with the grasses on the lawn. This machine can work for hours until the battery discharge or run off completely. The battery needs to be recharged before it can be used again. The set-up of the fabricated mower is shown in figure 1.



Figure 1: The fabricated solar powered lawn mower

The solar powered lawn mower was and tested in front of the Faculty of Engineering and Technology, Oyo State College of Agriculture and Technology Igboora with stubborn grass and soft grass, with a height of 100mm and 80mm respectively. The cutting time was recorded and the cutting efficiency was also determined using equation 1.

$$\text{Cutting Efficiency} = \frac{\text{Portion cut by lawnmower}}{\text{Portion of lawn}} \times 100 \quad (1)$$

As shown in Table 1 and Table 2, the machine spends more time cutting stubborn grass than on soft grass and has a higher cutting efficiency on soft grass when compared with stubborn grass.

With the solar panel mounted, which charges the battery more during daytime, the time taken for the battery to drain off increases during insolation hours and reduces as the sun sets.

Table 1: Performance efficiency of the Mower for Stubborn Grass

No of trials	Area of Lawn (m <sup>2</sup> )	Stubborn Grass			Efficiency (%)
		Portion of cut by the mower (m <sup>2</sup> )	Portion of uncut by the mower (m <sup>2</sup> )	Time taken to cut the portion	
1	40.0	33.0	7.0	70minutes	82.5
2	40.0	32.0	8.0	68	80
3	40.0	32.4	7.2	72	81

Table 2: Performance efficiency of the Mower for Soft Grass

No of trials	Area of Lawn (m <sup>2</sup> )	Soft Grass			Efficiency (%)
		Portion of cut by the mower (m <sup>2</sup> )	Portion of uncut by the mower (m <sup>2</sup> )	Time taken to cut the portion	
1	40.0	36.0	4.0	60	90
2	40.0	36.4	3.6	65	91
3	40.0	35.0	5.0	62	87.5

## CONCLUSION.

A Solar powered lawn mower was designed, fabricated and tested at the faculty of Engineering, Oyo state college of Agriculture and technology, Igboora. The efficiency of the machine on stubborn and soft grass was discovered to be 81 and 89.5% respectively. With the solar panel mounted, which charges the battery more during daytime, the time taken for the battery to drain off increases during insolation hours and reduces as the sun sets. The machine reduces the effect of environmental pollution causes by the emitted flames from the Lawn mower driven by internal Combustion engines and also taps into the potentials of the renewable energy.

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