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Design and Fabrication of Solar Grass Cutter

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Abstract: These days we are facing the problems like pollutions, power cut problem etc. In order to overcome these problems, we have thought about the device, which can be performing its functions without causing any of these problems. So we have thought of doing the project on cutting grass, this uses the renewable source of energy for its operation like solar energy. This project aims at developing a portable solar operated grass cutting device, as there is power shortage. So it was decided to make a solar energy operated device. Solar panel is connected to the battery. Battery is in turn connected to a DC motor. This motor is connected to blade shaft by the help of spur gears. This will rotate the blade in high speed as per the gear ratio and cut the grass. This device will help in building of eco-friendly system.

Keywords: AC, DC Motor, N-Type, P-Type, PV Cell

1. Introduction

Solar grass cutter is also known by the name solar lawn mower. A lawn mower is a machine that uses one or more revolving blades to cut lawn to an even height. The blades may be powered either by hand pushing the mower forward to operate the mechanical blades or may have an electric motor or an internal combustion engine to spin their blades. Some mowers also include other abilities, like mulching or collecting their clippings. An electrical Lawn Mower is more suitable & easy to use than the lawn mower with an engine. A Solar grass cutter is a machine that uses sliding blades to cut a lawn at an even length. Even more sophisticated devices are there in every field. Power consumption becomes essential for future. Solar grass cutter is a very useful device which is very simple in construction. It is used to maintain and upkeep lawns in gardens, schools, colleges etc. Rapid growth of various high-tech tools and equipment makes our jobs done in comfortable and sophisticated manner. The project aims at fabricating a grass cutting machine system which makes the grass cutter working through motor that runs using solar energy. Power plays a great role wherever man lives and works. Grass cutter machines have become very popular today. Most common machines are used for soft grass furnishing.

Fig. 1 cutter blade

2. Literature Survey

Everett G [1], the first lawn mower was invented by Edwin Budding in 1827 in Thrupp, just outside Stroud, in Gloucestershire. Budding's mower was designed primarily to cut the grass on sports grounds and extensive gardens, as a superior alternative to the scythe, and was granted a British patent on August 31, 1830. Budding's first machine was 19 inches (480 mm) wide with a frame made of wrought iron. The mower was pushed from behind. Cast iron gear wheels transmitted power from the rear roller to the cutting cylinder, allowing the rear roller to drive the knives on the cutting cylinder; the ratio was 16:1. Another roller placed between the cutting cylinder and the main or land roller could be raised or lowered to alter the height of cut. The grass clippings were hurled forward into a tray-like box.

Mary Bellis [2], in the United States, gasoline-powered lawn mowers were first manufactured in 1914 by Ideal Power Mower Co. of Lansing, Michigan, based on a patent by Ransom E. Olds. Ideal Power Mower also introduced the world's first self-propelled, riding lawn tractor in 1922, known as the "Triplex". The roller-drive lawn mower has changed very little since around 1930. Gang mowers, those with multiple sets of blades to

cut a wider swath, were built in the United States in 1919 by the Worthington Mower Company.

Hessayon D G [3], rotary mowers were not developed until engines were small enough and powerful enough to run the blades at sufficient speed. Many people experimented with rotary blade mowers in the late 1920s and early 1930s, and Power Specialties Ltd. introduced a gasoline-powered rotary mower. Kut Kwick replaced the saw blade of the "Pulp Saw" with a double-edged blade and a cutter deck, converting the "Pulp Saw" into the first ever out-front rotary mower. One company that produced rotary mowers commercially was the Australian Victa company, starting in 1952. Its mowers were lighter and easier to use than similar ones that had come before. The first Victa mowers were made at Mortlake, an inner suburb of Sydney, by local resident Mervyn Victor Richardson. He made his first model out of scrap in his garage. The first Victa mowers were then manufactured, going on sale on 20 September 1952. The new company, Victa Mowers Pty Ltd, was incorporated on 13 February 1953.

Gu Guanhui et al. [4] The venture was so successful that by 1958 the company moved to much larger premises in Parramatta Road, Concord, and then to Milperra, by which time the mower incorporated an engine, designed and manufactured by Victa, which was specially designed for mowing, rather than employing a general-purpose engine bought from outside suppliers. Two Victa mowers, from 1958 and 1968 respectively, are held in the collection of the National Museum of Australia. The Victa mower is regarded as something of an Australian icon, appearing en masse, in simulated form, at the opening of the Sydney Olympic Games in 2000.

3. Components

The solar grass cutter also known as the solar lawn mower has some specific part used in it so as to take out its function intended to do. As our project is focusing on the use of solar power, storing it in the battery and then using it to run the motor that in turn rotates the cutting blades and wheel. The main components used in the project are:

1. Solar panel
2. Battery
3. 12 V DC motor
4. Cutting blades
5. Spur Gears
6. Bearings
7. Sheet metal
8. Metal rods

3.1 Solar Panels

Solar panels are devices that convert light into electricity as shown in Fig.3.1. They are called "solar" panels because most of the time, the most powerful source of light available is the Sun, called Sol by astronomers. Some scientists call them photovoltaic which means, basically, "light-electricity. This is the basis of photo-voltaic conversion that is the conversion of solar energy into electrical energy. The combination of n-type and p-type semiconductors thus constitutes a photo-voltaic cell or solar cell. All such cells some rate direct current that can be converted into alternating current it desired. Future cells may use such materials as the semiconductors like Gallium arsenate, copper sulphate, cad sulphide etc. The device used to utilize the photovoltaic effect is solar cell.

Fig. 2 solar panel

3.2 Battery

Batteries convert chemical energy directly to electrical energy. A battery consists of some number of voltaic cells. These voltaic cells consist of certain chemical compositions where the chemical reactions takes places.Each cell consists of two half cells conneted by a conductive electrolyte containing anions and cations.

One half-cell includes electrolyte and the negative electrode, the electrode to which anions (negatively charged ions) migrate; the other half-cell includes electrolyte and the positive electrode to which cations (positively charged ions) migrate. Redox reactions power the battery. Cations are reduced (electrons are added) at the cathode during charging, while anions are oxidized (electrons are removed) at the anode during charging. During discharge, the process is reversed. The electrodes do not touch each other, but are electrically connected by the electrolyte.

Fig. 3 battery

3.3 DC Motor

A DC motor is a mechanically commutated electric motor powered from direct current (DC). The stator is stationary in space by definition and therefore so is its current. The current in the rotor is switched by the commentator to also be stationary in space. This is how the relative angle between the stator and rotor magnetic flux is maintained near 90 degrees, which generates the maximum torque. DC motors have a rotating armature winding (winding in which a voltage is induced) but non-rotating armature magnetic field and a static field winding (winding that produce the main magnetic flux) or permanent magnet. Different connections of the field and armature winding provide different inherent speed/torque regulation characteristics. The speed of a DC motor can be controlled by changing the voltage applied to the armature or by changing the field current. The introduction of variable resistance in the armature circuit or field circuit allowed speed control. Modern DC motors are often controlled by power electronics systems called DC drives.

3.4 Blades

Mower blades are the cutting components of lawn mowers. They are usually made of sturdy metals as they must be able to withstand high-speed contact with a variety of objects in addition to grass. The materials used (as well as size, thickness, and design of the blades) vary by manufacturer. The first known lawn mower sported a cylinder cutting gear made of iron. It was used to mow sporting grounds and wide-ranging gardens. As manufacturers changed the design and structure of mowers, the cutting mechanism also developed and evolved into several varieties, including cylinder/reel blades, deck blades, mulching blades and lifting blades.

3.5 Spur Gears

A gear or cogwheel is a rotating machine part having cut teeth, or cogs, which mesh with another toothed part to transmit torque. Geared devices can change the speed, torque, and direction of a power source. Gears almost always produce a change in torque, creating a mechanical advantage, through their gear ratio, and thus may be considered a simple machine. The teeth on the two meshing gears all have the same shape. Two or more meshing gears, working in a sequence, are called a gear train or a transmission. A gear can mesh with a linear toothed part, called a rack, producing translation instead of rotation.

3.6 Bearing

A bearing is a machine element that constrains relative motion to only the desired motion, and reduces friction between moving parts. The design of the bearing may, for example, provide for free linear movement of the moving part or for free rotation around a fixed axis; or, it may prevent a motion by controlling the vectors of normal forces that bear on the moving parts. Most bearings facilitate the desired motion by minimizing friction. Bearings are classified broadly according to the type of operation, the motions allowed, or to the directions of the loads (forces) applied to the parts.

3.7 Sheet Metal

Sheet metal is metal formed by an industrial process into thin, flat pieces. Sheet metal is one of the fundamental forms used in metal working and it can be cut and bent into a variety of shapes. Countless everyday objects are fabricated from sheet metal. Thicknesses can vary significantly; extremely thin sheets are

considered foil or leaf, and pieces thicker than 6 mm (0.25 in) are considered plate. Sheet metal is available in flat pieces or coiled strips. The coils are formed by running a continuous sheet of metal through a roll slitter.

3.8 Metal Rods

Metal rods also termed as a hollow structural section (HSS) is a type of metal profile with a hollow tubular cross section. The term is used predominantly in the United States, or other countries which follow US construction or engineering terminology. HSS members can be circular, square, or rectangular sections, although other shapes such as elliptical are also available. HSS is only composed of structural steel per code. HSS is sometimes mistakenly referenced as hollow structural steel. Rectangular and square HSS are also commonly called tube steel or structural tubing. Circular HSS are sometimes mistakenly called steel pipe, although true steel pipe is actually dimensioned and classed differently from HSS.

4. Design and Calculations

The project is designed to use the renewable source of energy as in solar energy and use it to drive a cutter fitted with different accessories and cut the lawn grasses and collect it too. The grass cutting blade of spiral shape is linked with the spur gear mechanism which is driven by a battery where the charge is stored via solar panel.

The cutting blades are covered with a sheet metal so as not to let the cut grasses spread away and also a sheet metal basket is kept at the back end where the cut out grasses are collected. The whole structure is supported in a frame work of metal rods. Solar panel is fixed in the structure and is charged when the system is not working and the charge thereby is transferred to the battery by the circuit. The proposed design of the model is shown in the Fig. 4.1.

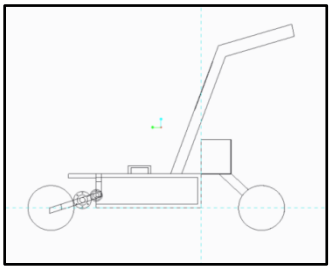

Fig. 4 proposed model

For the starting up design, the sketch up software as shown in the Fig. 4 was used to build the body frame, which would allow it to know the dimensioning for the basket to hold the grasses and that for the blade section. Even though the real fabrication of the part is varying the original design, the main structure was retained from this preliminary concept. The main structure holds the chassis, the basket, blades, spur gears, solar panel. The main variation from the design was the placement of the solar panel which was fixed in the body.

Fig. 5 3D modeling

4.1 Specifications

No of Teeth in Pinion =24
No of teeth in Gear = 60
Gear ratio = 2.5
Diameter of Gear = 10.5

4.2 EQUATIONS

Force required by cutting blade to shear the grass is given by;

$$F = T/R \quad \ldots (1)$$

Where,
T = Shaft torque
R = Radius of cutting blade
But shaft torque is given by;
$T = P/2\pi N$ … (2)
Electrical Power is given by;
$P = I * V$ … (3)
Torque of motor is given by;
$P= 2\Pi NT / 60$ … (4)
$T= (P*60) / (2\Pi N)$

4.3 Design Parameter

4.3.1. Selection of electric motor

A) DC motor SPEED (N) = 1250
B) RPM VOLTAGE (V) = 12 VOLT
C) WATTS = 18 WATT

4.3.2. Torque of the motor

A) Torque (T) = (P X 60) / (2 X 3.14 X N)
= (18X 60) / (2 X 3.14 X 1250)
= 0.1375Nm
i.e. Torque = 137.5 N-mm
B) The shaft is made of MS and its allowable shear stress = 42 MPa

4.3.3. Electrical (electric) power equation

A) Power (P) = I × V
Where, V = 12 V
P = 18 W
Then, I=18/12
=1.5 A
B) In hp = 0.02414hp

4.3.4. Solar panel calculation

A) VOLT = 18 V
B) WATT=10W
C) W = V X I
10 = 12 X I
I = 10/18
=0.566 A
i.e. I=566 mA

5. Conclusion

The main aim of the project is to design and fabricate an eco-friendly device named as the solar grass cutter. There had been many attempts in the past too for making a device that cuts the grasses but were mainly focused on use of the muscle power either human or animals. Also development has led towards the utilization of electric power in order to move lawn mower. Now the world is facing energy crisis and people are more focused towards using renewable energy source for every activities that is being consuming the non-renewable resources. Likewise the power consumption of grass cutter has been modified towards the solar sector which is one of the renewable energy sources. Due to this technology, global problem of pollution has been reduced and a green technology has been introduced.

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