A Technical Review of Lawn Mower Technology

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Abstract: This paper summarizes and reviews different technological developments for making efficient and cost effective lawn mowers. Such lawn mower may be powered by solar energy, conventional electric and internal combustion engine. For each type of energy source mentioned above, we discuss the mechanisms followed for lawn mower device, the design of the model and results obtained in various literatures. Sometimes two such energy sources may be used in combination, like solar powered robotic lawn mower.
Keywords: lawn mower, solar energy, sensor, motor, battery, exhaust.

1. Introduction

A lawn mower is a machine that is used to cut grass in a lawn. The blades of the lawn mower are generally powered by pushing the mower forward. Lawn mowers are classified based on different criteria. For example, according to the axis of rotation of blades we may have reel lawn mowers (in which the axis is horizontal) and rotary lawn mowers (in which the axis is vertical).The reel (cylindrical) lawn mower is found to be better. Made of blades on a revolving cylinder, they achieve clean cut by scissors action. As the mower moves forward, the rotating blades come in contact with a stationary bar called the bed knife and placed parallel to the ground. The mower is adjusted to various cutting heights. Rotary mowers are often powered either by an internal combustion engines or an electric motor and are generally mowed manually, with the engine only spinning the cutting blades. Rotary mowers are generally have opening by the side of the housing through which cut grasses are expelled. Some are attached with a grass collector at the exit point. The blade is seldom sharp enough to give a neat cutting point. The blade simply cuts the grass resulting in brown tips.However the horizontal blades are easy to remove and sharpen or replace. Again based on the energy source we may have gasoline driven, electricity driven or hand driven lawn mower. Over the years, there have been numerous developments in lawn mower technology. But with technological advancement there also arises the need to check the impact of machines on the environment
as well as on man. Pollution is the major concern with the conventional gas powered lawn mower. Human effort is another factor that needs to be reduced. In this paper we look at different mechanisms that have been innovated to increase efficiency of lawn mower operation and research development work going on in respective designs.

2. Solar Powered Lawn Mower Models

Dipin and Chandrasekhar [1] studied solar powered vision based Robotic Lawn Mower. It showed the design of a microcontroller and sensor based robotic lawn mower mechanism. This robotic mowing device was solar powered and its battery gets charged from sunlight while mowing on the lawn or even manually. Ultrasonic sensors were used for avoiding obstacles and humidity sensor for checking humidity level in the lawn. Passive infrared sensor (PIR) was used to detect human interaction near the device in operation. Android smart phone was used for capturing images of the lawn as per requirement. This design is targeted as an alternate green option against the popular but environmentally hazardous gas powered lawn mower. The design is built on a mobile robot which communicates with a computer through a zigbee module. A GUI (Graphical User Interface) has been created in MATLAB for the selection of cutting design/pattern of the lawn by the operator**.**
Tanimola et al. [2] studied on design and development of a solar powered lawn mower. They tried to achieve a solar powered lawn mower model that used solar energy with the help of a solar panel and solar photovoltaic cells to run an electric motor. The electric motor was coupled to the cutting blades. The photons from sun hit the photovoltaic cell and as a result, flow of electrons start leading to direct current. A 1.5 HP (Horse Power) motor is used and a 12 volt battery supply electric power to run the motor. They performed detailed analysis to estimate the torque produced in the blade and whether it is sufficient to perform the intended job. Also stress analysis was performed for the frame and the handle of the lawn mower. After design and development of the lawn mower, it was tested on four different species of grass.

Satwik et al. [3] performed design and fabrication of lever operated solar lawn mower and contact stress analysis of spur gears. They tried to develop a height adjustable mechanism for the cutting blade. The mechanism involves a pair of spur gears of different face width and a lever which adjusts the rotor height such that the smaller spur gear slides on the face width of the larger spur gear. An arduino board was used to control the speed of the rotor blade and obstacle detection. Solar panel receives sunlight and powers the battery which in turn runs the motor. Battery and motor selection were done after design analysis of blade. Active stresses on the spur gears are calculated by using AGMA and Hertz equation and also Finite Element Analysis(Figure.1 and Figure.2).

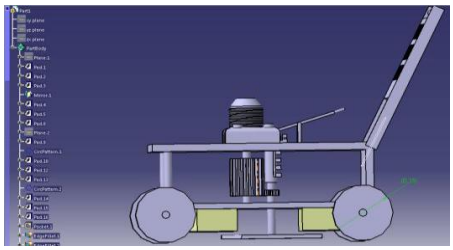

Figure 1: CAD model of lawn mowe

Figure 2: Gears mounted of different face widths

3. Automatic Lawn Mower Models

Newstadt et al. [4] studied on a Global Positioning System (GPS) aided autonomous lawnmower. They tried to develop an efficient hybrid lawn mower. It consisted of a modified DGPS (Differential global positioning receiver system), a modified chassis, new wheel encoders, a more advanced control system, digital compass and a safety system. Furthermore acoustic sensors and a laser ranging systems had been added in order to supply obstacle detection capabilities. The DGPS(Differential global positioning receiver system) system based on carrier phase measurements provided accuracy at the centimeter level. This lawnmower was lightweight, yet robust for operation. It was framed with angle iron. The mounting surfaces were shielded with high strength steel sheeting with plywood covering the steel. Furthermore, a shelving system was incorporated to offer the maximum flexibility to the layout and construction. A new shaft coupling mechanism was fabricated to link the gas engine to the alternator shaft and the engine. It consisted of control software to control the path planning through the remote base station for testing and monitoring purposes. The digital compass was used to compute the azimuth angle of a lawn mower. Furthermore, a reliable safety system wasimplemented onboard with a remote controlled emergency stop.

Patil et al. [5] studied on design and implementation of automatic lawn cutter. They developed a cordless automatic lawn mower so that the user could specify the area to be mowed and also the height of the grass as per their requirement by using the keypad. The design contains a microcontroller like *Atmega* 16, multiple sensors, Liquid Crystal Display (LCD)and keyboard. The microcontroller *Atmega* 16 was used for analog to digital conversions from the sensors. It also controls the speed of the wheels. The battery can be charged by using power supply and solar panel. A sensor ADXL335 is used which is an accelerometer to detect orientation based on pre calibrated axis orientation. Further a high performance sonar module is used to detect an object in its vision from 20 feet away. And for inserting input a keyboard is used. Three (Direct Current) DC motors are used. One (Direct Current) DC motor is connected to the linear blade and others are connected to the wheels. Ray Jarvis [6] studied on tele-autonomous heavy duty robotic lawn mower. It concerned with development of a heavy duty lawn mowing machine that was richly instrumented with sensors and computational support. This provided a hybrid capability between pure tele-operation and full automation. In this model the author used a tri-level control strategy where the three levels of control were reactive (low level), anticipatory (middle level) and planning (top level). The two lower levels (reactive and anticipatory) basically provide local support for obstacle collision avoidance at both an imminent and local level, with the top level planning being provided by the operator. The instruments used in the model were Erwin Sick scanning laser range finder (up to 50 meters range), Phase mode/ Differential Global Positioning System Optical Gyroscope (with vertical axis), Stereo Video Camera Pair, Web Camera (with its own IP address), Long Range Laser Rangefinder (up to 400 meters),Denning Bar Code Reading Localizer (up to 30 meters) etc.Chandler et al. [7] reported on the next generation autonomous lawn mower. The developed autonomous lawnmower robot was capable of learning its environment through training. Once learned, the robot would be capable of navigating through its environment that avoided obstacles by means of its sensors. The mower could operate using machine learning techniques. This allows the mower to recognize objects in the mowing area like flower beds, sidewalks, trees, driveways, etc., using computer vision. The use of vision will allow the mower to determine whether it is cut or uncut grass and act accordingly in a pattern. The mower would need training by a human operator in order to learn what objects to avoid and where and how to mow. If the mower realizes where a bare patch of yard is, it can release fertilizer to promote the growth of grass, or release ant killer if it comes across an ant hill. This makes the mower a "lawn maintainer" instead of just a lawnmower. Sensors for obstacle avoidance and range detection were computer vision system, infrared sensors and sonar. A local positioning system (LPS) allowed the mower to know where it was in the yard. All these sensors combined so that the mower can make informed decisions about its environment. The mower would also need to charge its batteries. This is done with the help of a charging station placed somewhere in the mowing area. Singh and Singh Mehta [8] performed design and analysis of wireless remote controlled lawn mower. They tried to make a smaller, lighter, efficient, environment friendly and direct current powered lawn mower for better handling and endurance. An adjustable cutting height motor was introduced for better mowing of grass at intricate locations (Figure.3). An innovative design was made and stress and deflection analysis was performed by using ANSYS (Figure.4, Figure.5). The stresses developed and deflection of various elements of mower has been shown in the form of colour coding.

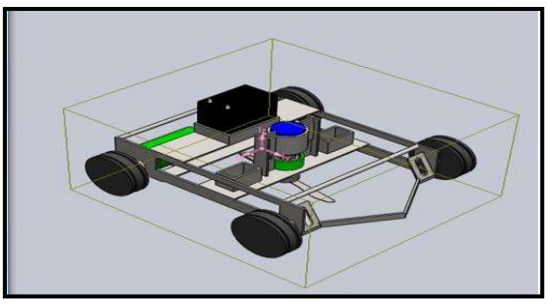

Figure 3: CAD model

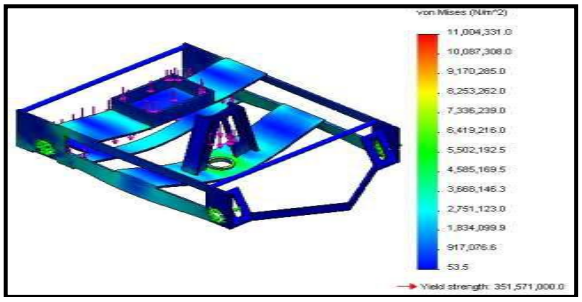

Figure 4: Von Mises Stress

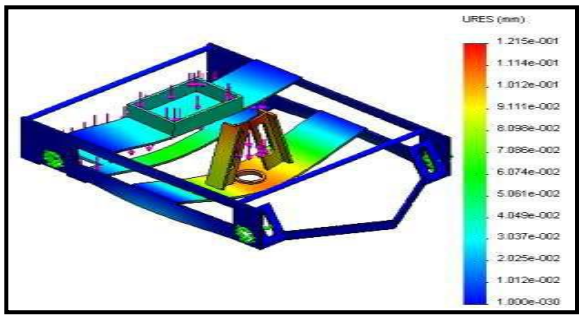

Figure 5: Deflection of base

Sujendran and Vanitha P [9] reported on smart lawn mower for grass trimming operation. They presented a model of an automated lawn mower that consists of linear blades operated with the help of a motor. The power supply of the motor was a battery that could be charged either by electricity.

or by solar panel. An infra-red sensor was provided for obstacle detection that prevents possible hardware damage. A path planning algorithm was proposed by the authors in whom they tried to achieve three modes-minimum time mode, minimum energy mode and mixed mode. However, this was a compromise between the other two modes. As shown in the circuit diagram, the battery runs the motor this in turn actuates the blades. The solar panel recharges the battery. The height of cutting is adjusted by means of a link mechanism via a lift rod. A simple flow chart provided by the authors for the movement of the lawn mower is given in (Figure.7).

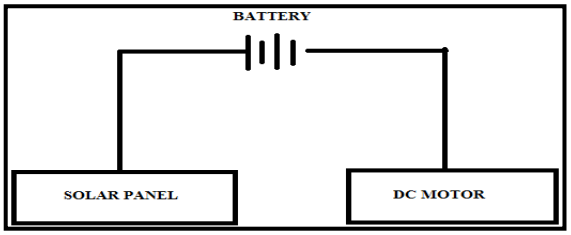

Figure 6: **Circuit diagram of the model**

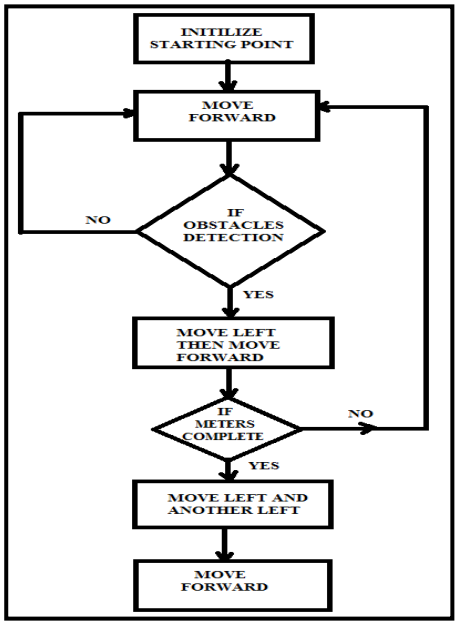

Figure 7: **Flow chart of the model**

4. Gas Powered Lawn Mower Models

Gabele [10] reported on exhaust emissions from four stroke lawn mower internal combustion engines. The studies characterized exhaust emissions from new and in use four stroke lawn mower engines. The impact of reformulated fuel on emission rates and composition was examined by testing two fuels: (1) A 1990 baseline gasoline and (2) A California Reformulated Gasoline (CaRFG) Program. The various instruments used for the test experiments were emission analyzers, engine dynamometer controller and constant volume sample that were used to collect the data during the exhaust emissions test. The data were entered into the computer in real time. Exhaust gas emissions were generated by operating the engines over the composite six mode test cycle. The exhaust emissions test were conducted on 10 engines which had different values of displacement, age and time in use, rated power, maximum test torque and different types of valves. It was found that as compared to the to the baseline gasoline, the reformulated was an oxygenated fuel that has lower olefin and aromatic levels, lower T 90 (temperature at which 90% of the fuel boils-off), and lower Reid vapor pressure. The (California Reformulated Gasoline) CaRFG Program gasoline also had a lower sulfur content that enabled catalysts to operate at higher conversion efficiencies in reducing pollutant emissions. The author concluded that lower NMOG (non methane organic gas), CO(Carbon monoxide) , RWE (reactivity weighted emissions) and aggregate toxic emission rates were observed with the newer mowers and with the reformulated gasoline.

Conversely higher NO_x emission rates were observed with these same engines and fuel.

5. Studies Undertaken by Authors

With the literature reviews presented above, an effort has been directed to design a low cost manual / power operated lawn mower. For development of the lawn mower locally available standard parts and materials will be utilized considering the low cost and development simplicity factors. The computer aided drafting of the proposed low cost lawn mower is presented in Figure.8 below.

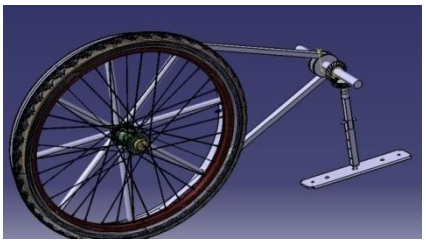

Figure 8: CAD model of propped low cost lawn mower

Our aim is to design and fabricate a manually pushed lawn mower model of simple mechanism and low cost. A large pulley will be coupled to the driving wheel. A smaller pulley will be joined with the larger pulley through a belt drive. A bevel gear pair will transmit power from the smaller pulley to the cutting blades.

6. CONCLUSIONS

It has been observed that literature pertaining to lawn mower design and development is comparatively lesser. In the present studies, different aspects of solar powered, plug on electric, guided lawn mower have been presented. With this background, the present studies direct design and development of a low cost manual / electric lawn mower. It has also been observed that the technological variations of commercially available lawn mower are not abundant. Mostly domestic lawn mowers are powered with gasoline engine and operating cost for such lawn mower is around Rs.300-400/- per day excluding labour charges. It is expected that low cost improved manual / electric lawn mower once developed, the operating cost for such system is expected to come down in future.

REFERENCES

[1] A.Dipin and T.K .Chandrashekhar , "Solar powered vision based robotic lawn mower," International Journal of Engineering Research and Reviews ,vol. 2, pp: 53-56, April 2014 - June 2014.

[2] O. A Tanimola, P. D Diabana, and Y. O. Bankole ,"Design and development of a solar powered lawn mower," International Journal of Scientific & Engineering Research, vol. 5,June-2014.

[3] D.Satwik, N.Ramalingeswara Rao, SreeramReddy, "Design and fabrication of lever operated solar lawn mower and contact stress analysis of spur gears," International Journal of Science, Engineering and Technology Research, vol. 4, August-2015.

[4] G. Newstadt , K. Green, D. Anderson, M. Lang, Y. Morton, and J. McCollum , "Miami Redblade III: A GPS-aided Autonomous Lawnmower".

[5] P. Patil, A. Bhosale, S. Jagtap, " Design and implementation of automatic lawn cutter,"

[6] Ray Jarvis , "A tele-autonomous heavy-duty robotic lawn mower," proc.2001 Australian conference on Robotics and Automation Sydney, Nov 14-15,2001.

[7] Rand C. Chandler, A. Antonio Arroyo, Michael Nechyba , Eric Schwartz , "The next generation autonomous lawn mower," 2000 Florida Conference on Recent Advances in Robotics, May 4-5, 2000, Florida Atlantic University.

[8] H. Singh, J. Singh Mehta, "Design and analysis of wireless remote controlled lawn mower,"SSRG International Journal of Mechanical Engineering, April 2015.

[9] S. Sujendran, P. Vanitha , "Smart Lawn Mower for Grass Trimming," IJSR **,**vol 3, Issue 3, March 2014

[10] Peter Gabele , " Exhaust emissions from four stroke lawn mower engines," Journal of Air & Waste Manage. Assoc. 47:945-952, vol. 47, Sept.1997.

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