Design and Fabrication of Electric Power Weeder

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Abstract

One of the main problems for the farmers in India is weed control in crops. Generally, Indian farmers use the traditional way of weeding which is done by laborers or bulls. Even though this method is an efficient one it requires huge demand for labor. In this paper, we are going to discuss the design and fabrication of an electric power weeder, which is a sustainable and efficient alternative to conventional manual weeding. Our motive is to develop a cost-effective and efficient solution that can replace traditional weeding methods. The electric power weeder is equipped with an electric BLDC motor, BLDC controller, Lithium-ion battery, and a set of specially designed cutting blades, which can remove weeds from agricultural fields without damaging the crops. The weeder is driven by a man to move in the forward direction and the blade attached at the front end is placed at the roots of weeds, once the blades get rotated then they start cutting the weed. The design of the weeder is optimized for ease of use, portability, and low maintenance, making it suitable for use by small-scale farmers and gardeners. The fabrication process is detailed, including the selection of materials, the assembly of components, cutting, drilling, welding, and the testing of the final product. The results of field trials demonstrate the effectiveness of the weeder in removing weeds and improving crop yields. The electric power weeder has the potential to reduce the time and labor required for weeding, while also promoting sustainable agricultural practices.

Keywords: *Weeds, BLDC motor, BLDC controller, Blades.*

1. Introduction

One of the most challenging tasks in agriculture, weed management makes up a considerable portion of the cost of agriculture output. Weeds are unwanted plants that compete with main crops for water, light, and nutrients. In general, farmers voiced their concern for effective weed control strategies to halt weed development and spread. In Indian agriculture, removing unwanted plants by hand or using bullock-powered machinery can be highly laborious and even dangerous for major crops. More than 33 percent of the costs associated with cultivating the land are redirected to weeding activities, lowering the farmer's profit margins. This plant competes with crops for nutrients, light, and water. Crop productivity may be affected by this. There are some weeds that are useful, but they are rarely found growing alongside crops. It causes major damage till the crop is harvested. Due to these weeds, there is a loss of 10 to 37% in yields. Many weeds are 2 times faster in extracting nutrients like nitrogen, calcium, and potassium than the main crop. So, the removal of weeds is essential for the benefit of farmers. Weed management is as old as agriculture itself, but the methods and concepts of controlling weeds have changed over the years. The weeds are more competitive during the initial stage of the main crop.

Controlling weeds currently is essential to maximize crop yield. We have many types of weed control processes such as Biological, Chemical, Manual, and Mechanical. In the manual method, traditionally we use labor and animal power but there is a huge demand for laborers, and it is uneconomical. In chemical methods, we can control weeds using weedicides, but it also affects the main crops which cause some problems for humans. In biological methods, we can't use this in all types of agricultural fields. It is a very high-cost operation. We can also remove weeds using agricultural tools, but it may damage the main crops. To overcome this problem, we are going to develop an electric power weeder. An electric power weeder is a device to remove weeds from agricultural fields and gardens using electrical power. This project involves several steps such as the selection of material, design of the weeder's structure, integration of electrical components, and fabrication of the weeder. Before selecting the material, which is used to construct the weeder, we should analyze the properties of the material such as strength, durability, density, conductivity, and corrosion resistance.

The weeder should be able to handle different types of soil and be able to remove weeds efficiently without damaging the main crops. Our weeder design should be effective for all types of farm sizes and able to withstand long periods of time without requiring frequent maintenance. Once we finalize the structural design, the electrical components can be integrated into the weeder. In the selection process of electrical components, we compared some parameters such as the motor's speed, torque, efficiency, control, lifespan, power cycle, and battery life to find the best component. After analyzing it we selected a BLDC motor, BLDC controller, and Lithium-ion battery as electrical components for our

weeder. This paper presents the design and analysis of an electric power weeder, which is an eco-friendly and cost-effective solution for weed removal.

2. Literature Survey

Bishal k Banjara et al. [1] developed and tested the battery-powered electric weeder. The weeder was designed and fabricated using locally available materials, and a lead acid battery. Its performance was evaluated in terms of weed removal efficiency and energy consumption. The results showed that the weeder was less effective in fields because lead acid batteries have a low energy density, and they are less efficient at storing energy. It affects the performance of the weeder. A. Arun et al. [2] designed and developed an electric weeder for small-scale farmers. The weeder was designed to be affordable and easy to operate, with a simple design and low maintenance requirements. The material used in the weeder is aluminium to reduce the weight and cost. Aluminium is a highly reactive material, and it is a very bad choice for weeder because in the field it can easily reacts with other material. When aluminium is exposed to salts or moisture there is a chance for corrosion. This material is very soft compared to others, so the strength of the material becomes low. By analyzing these properties of the material, the performance of the weeder gets affected.

K. Nithya et al [3] developed an electric-powered weed cutter for agricultural applications. The weeder was designed to be lightweight and portable, with a battery-powered motor. The results showed that the weeder was effective in dry lands but in wetlands, the weeder is not effective because of the load produced by the weeder. N. Venkateshwaran et al. [4] designed and fabricated the power weed remover. The weeder was designed to be lightweight and easy to use, with an ergonomic handle and adjustable cutting height. The results showed that the weeder was effective in removing weeds, but the use of a diesel engine requires fuel that is non-renewable that also requires a sizeable amount of money. It also emits toxic gases like carbon monoxide. It can be used in larger fields but is not suitable for smaller areas because of the vibrations produced by the diesel engine. It may affect the main crops. D. G. Sharma et al. [5] designed and fabricated of a handheld electric weeder. The weeder was designed to be lightweight and easy to use. The motor used in the weeder is an induction motor. It has poor speed control and is less efficient at loads. It consumes more power because of the lower power factor. The speed and control can’t be determined in this weeder because of the induction motor.

3. Identification of research gap

- To design and fabricate an efficient electric weeder and provide a solution to the farmers who are affected by weeds during crop cultivation.
- To make the electric power weeder affordable for small-scale farmers.
- To reduce the use of harmful pesticides for weed control and enhance the quality of food products.

- To reduce the process time and effort required for manual weeding.

4. Methodology

First, we identified the problem that arises for the farmers in the agricultural field. We discussed the weeds, problems in removing weeds, existing methods, and disadvantages of the existing methods. To overcome this problem, we are going to develop an efficient electric power weeder that is cost-efficient and easy to use. First, we have to identify the requirements for the electric power weeder. This process includes analysis of the size and weight of the weeder, efficiency of the weeder, selection of materials, selection of components, and other design requirements. After fixing the requirements, we must create a 3D model design of the weeder using solid works software. Then, we can stimulate the 3D model design using ANSYS software to find the efficiency of the weeder. After completing the design, we need to develop a prototype. It is tested to identify the issues in the design and performance of the weeder. Once the prototype is finalized, we can start the final fabrication process. This involves manufacturing the frame structure of the weeder, assembling the components, and testing the final product to ensure that it meets its specifications. The final stage is field testing and validation of the performance of the weeder in all conditions.

The power will be generated from the Lithium-Ion battery. It gives a constant power supply to the weeder. An E-Bike throttle is used to start and control the weeder. We can control direction and load using this throttle. The power Come from the battery to the BLDC controller and BLDC motor. The controller controls the speed and position of the motor precisely. The motor and chain sprocket will be connected. Once the motor starts rotating, the chain sprocket will also start rotating. The cage wheel and sprocket are welded using a 25mm Shaft. Hence, the sprocket makes the cage wheel rotate. The cage wheel is specifically designed to work in the agricultural field. The cage wheel consists of a series of metal bars arranged in a circular rim around a central axis. It will loosen the soil and make the weeding process easier.

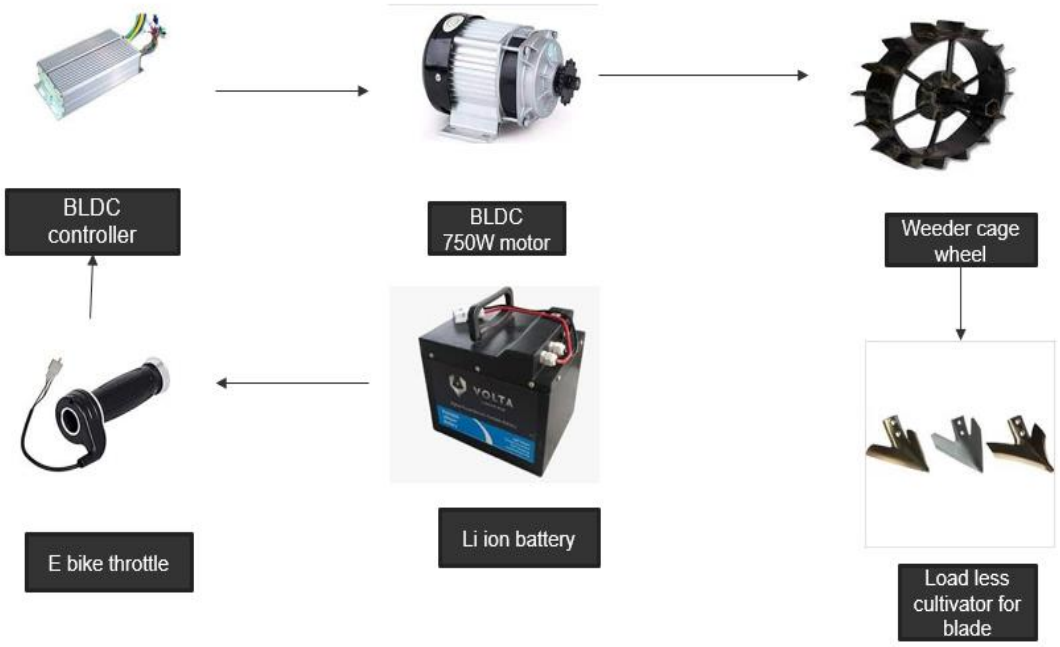

Figure 1 Overall Methodology

5. Software Design

The total dimension of the weeder is 33x42 Inches. The electric motor, the weeding blades, and the control system make up the three primary parts of the electric power weeder. A rechargeable Lithium-Ion battery powers the electric motor, which is a Brushless Direct Current motor. The output shaft's torque and speed are increased by the motor's connection to a chain sprocket. The cage wheel is connected to the chain sprocket's output shaft, and its rotation facilitates the forward motion of the weeder. An on/off switch, a speed controller, and a battery charger are all components of the control system. Depending on the type of weeds and the soil conditions, the speed controller modifies the speed of the engine and the blades. The design Figure 1 is done in solid works software.

Solid works is a popular Computer Aided Design (CAD) software that is used to create 3D models and drawings of parts and assemblies. Solid works offer a wide range of tools and help the designers to design, simulate and visualize the product. In solid works, there are many features like sketching, part modeling, assembly modeling, simulation, and collaboration. It is used to design and test the product in a virtual environment. It can be integrated with other software like 3D printer software for prototyping. It helps to save time and reduce costs in the fabrication and product development process. In our project, we used solid works to design the frame structure and chassis of the weeder. We designed a cage wheel, load-less cultivator blade, and frame of the weeder. It improves the accuracy and quality of the final product.

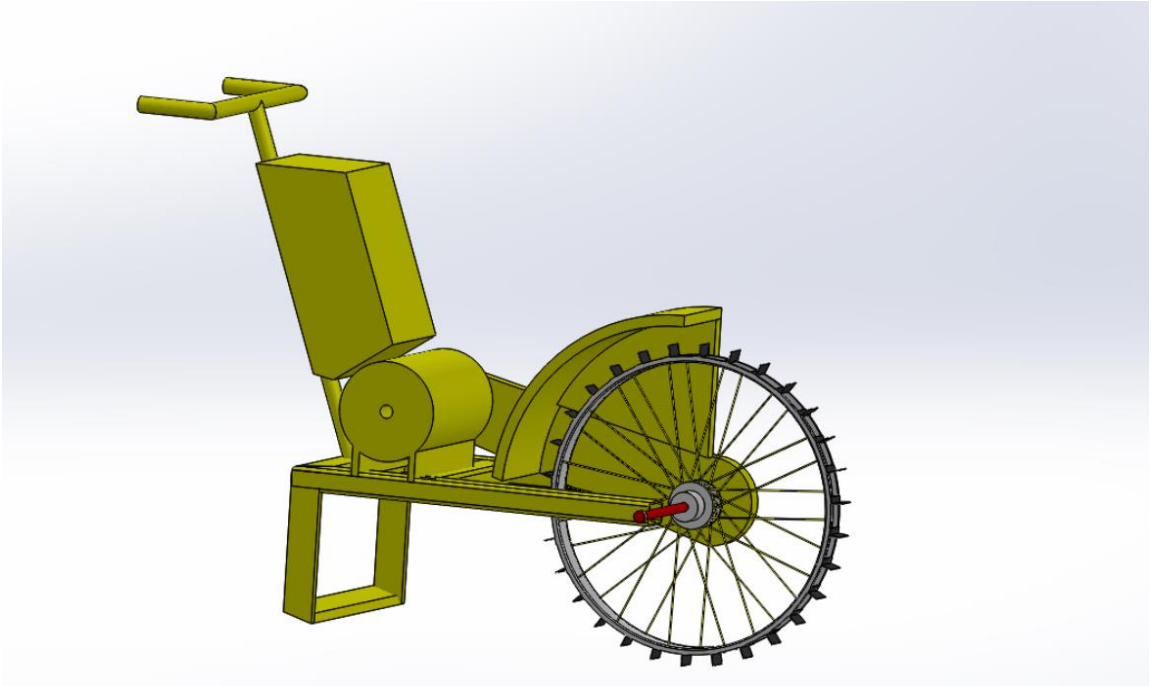

Figure 2 Software Design

6. Fabrication process

The electric power weeder is made with commonly accessible components and follows accepted manufacturing procedures. The AISI 4130 steel sheets that make up the machine's chassis are cut and welded together to create a robust frame. With bolts, the BLDC motor is fastened to the chassis. The cultivator-style, load-free weeding blades are manufactured of MS flat bar steel that has been chopped and sharpened. MIG welding is used to attach the blades to the weeder's back end. The battery is put inside a battery box that is clamped to the chassis. MIG welding is used in the welding process. The blade will be placed inside the land, and it makes the agricultural field weed free with less amount of time and effort.

We started with the cage wheel in the fabrication process. First, we attached the rim of the wheel with a bolt and nut. Then we selected AISI 4130 steel material for a series of metal bars in the circular rim. We designed the material in an L-shaped 5-inch bar to attach to the wheel. After that, we started the welding process. MIG welding is used in this process. By doing welding, we attached the L-shaped steel in the rim around the central axis. Using the 25mm shaft we connected the chain sprocket and cage wheel. Before that, we fixed the p607 bearings in both sides of the cage wheel. P607 bearings are generally used to reduce the friction between the shaft and cage wheel while the weeder is in operation. The Plummer block bearings are welded with the traction blade wheel for better locomotion in the weeder. Once the chain sprocket starts rotating then the cage wheel also

starts rotating. It makes vibration less operation in the weeder and more efficient in the agricultural field.

The frame structure for the weeder is a very essential one because it has to carry all the weight, withstand the load and it must be lightweight, portable and compact to use. We selected AISI 4130 steel material for the frame structure because it is light in weight, very strong, corrosion resistant and all the other physical properties are suitable for the electric weeder. The weeder is run in the agricultural field and the field is very rough, the soil has some moisture content, and there is the possibility of chemical reactivity with the material and some other factors. So, material selection is very important in the weeder. AISI 4130 steel is suitable for the agricultural field. The dimension of the weeder is 33x42 inches. We fabricated the frame by doing welding, grinding, cutting and lathe work. After completing the frame structure, we designed the handle for the weeder. It is a U-shaped handle that's suitable for our weeder design. We designed the blade using a load-less cultivator mechanism to decrease the load in the weeder. MS Flat bar is used to fabricate the blade.

Once the manufacturing part is done assembly is the important and final part of the fabrication process. After completing the manufacturing assembly makes the weeder into the finished product. The cage wheel and chain sprocket are fixed on the front side of the weeder. Sprocket relates to the BLDC motor. The motor makes the sprocket rotate and the cage wheel also rotates in the forward motion. The BLDC motor is fixed in the base of the motor. Lithium-Ion battery is placed in the battery box separately. The load-less cultivator-type blade is fixed in the back end of the weeder. It will take care of the weeding process. The E-Bike throttle is fixed in the handle, and it controls the direction. After completing this process, we have to test the weeder in the field.

Electrical components used in the weeder are a BLDC motor, BLDC controller, Lithium-Ion battery, 48V-12V step-down converter and E-Bike throttle. BLDC motor is a 750W three-phase motor and the Lithium-Ion battery is 48V 31.2AH. BLDC controller connects with a step-down converter to maintain the voltage rate in the circuit. Cathode and Anode in the Lithium-ion battery relate to the BLDC controller's positive and negative respectively. The power supply comes from the battery, and it passes through the controller. The stepdown converter reduces the voltage that goes to the motor. Three-phase relates to the controller and the voltage passes through controller to motor. It controls the speed and position of the motor precisely.

7. Working of Weeder

- Start the weeder with the help of on/off switch in the E-Bike throttle. We can control the direction and load of the weeder using this throttle.
- Battery is used to supply the power to controller and controller gives supply to motor. The motor is used to transmit electrical energy into mechanical energy.

- BLDC motor speeds around 5000 RPM which makes the weeder to move faster. The efficiency of the motor is 85% and it has a longer lifespan than others.
- The battery cycle for the Lithium-Ion battery is 3000-5000 cycles. Hence, the charging speed and working time of the weeder is very high in the field.
- Once the motor starts rotating the cage starts to move in the forward direction with the help of a chain sprocket.
- The speed of the weeder in the forward direction is 10 km/hr and in the reverse direction it can go up to 5 km/hr.
- The load-less cultivator blade is sharpened by the grinding process. The blade is placed inside the soil. The cage loosens the soil, and the blade removes the weeds in the field.
- When the cage wheel starts rotating forward motion occurs in the weeder. P607 bearings are fixed on both sides of the weeder. It reduces the friction of the cage wheel when the operation occurs.
- Hence, the weeding process is done with less time and effort.

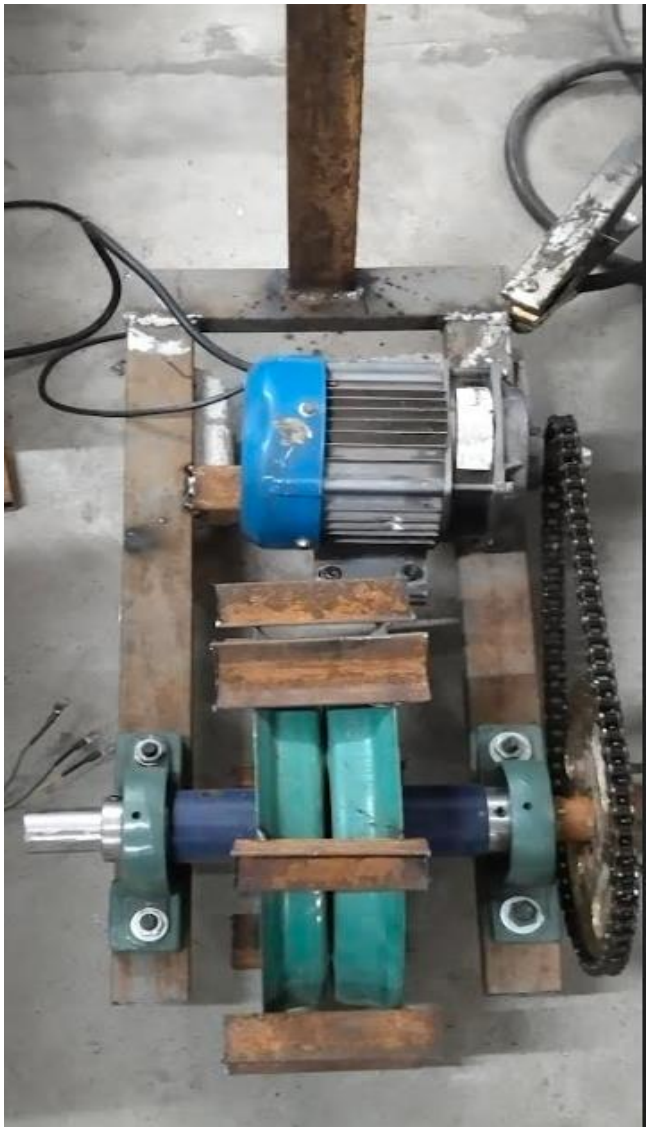

Figure 3 Development of Product

8. Results and Discussion

This chapter deals with the outcome of the research and field test of the weeder. This electric weeder is designed and built to be compact and efficient in weeding. We tested the machine in the field to check the speed of operation, weeding ability, runtime, efficiency, and vibration. The performance of the machine in the test results is successful in the field. The cost of this electrical weeding process is very less compared to other types of weeders. In fuel type weeder, we need to use one litre of fuel for 0.45 hours of the weeding process. The cost of operation for one hour is Rs.123. In our electric weeder, to charge the battery we need 1.2 units of electricity, and the cost is 10 rupees. Once the battery gets fully charged, we can operate the weeder for up to 6.5 hours. The cost of the weeding process is reduced by 12 times. We can compare the runtime of both weeders. The runtime for the fully charged electric weeder is 6.5 hours while the runtime of the fuel type weeder is 0.45 hours per litre. The runtime of electric weeder is 15 times more than the fuel-type weeder. The loading capacity of the electric weeder is 2 times higher than the fuel-type weeder. The loading capacity of the electric weeder is 490 kg and for the fuel-type weeder is 250 kg. The manufacturing cost of a single weeder is Rs.45,000. We are designing this electric weeder to overcome the problems with the currently available weeder in the market. Hence, we compare both the weeders,

Table 1 Comparison Table

Comparison Test	**Electrical Weeder - Propos**	**Fuel Weeder - Existing**
Speed of Operation	4.6-10 km/hr	3.5 km/hr
Runtime	6.5 hrs	0.45 hrs per litre
Digging Depth	75-150 mm	170 mm
Loading capacity	490 kg	250 kg
Soil type	Both dry and wet soil	Both dry and wet soil
Cost of operation	2.5 rupees per hour	123 rupees per hour

9. Conclusion

An economical and environmentally beneficial method of weed control in agriculture is the electric power weeder. The machine's construction and design are simple, and small-scale producers can easily copy them. In various field tests, the machine's performance

has shown encouraging signs. The electric power weeder has the power to transform the weeding procedure and advance sustainable agriculture. It is possible to conduct an additional study to improve the machine's functionality and investigate its uses with various crops and soil types. The work necessary to create a weeder will satisfy the farmer's demand. The effectiveness of the weeder should be acceptable, and it is simple to use. It was quicker than the standard weed-removal procedure. Compared to manual weeding, it requires less work and is more cost-effective. As a result, maintenance costs are quite low. The cost of weeding with this equipment is only a third of what it would be with manual labor. Low-cost Weeder is made from materials that are readily available in the area. We assessed all the parameters in the result and the weeder's overall performance was satisfactory.

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