

## Design and Development of Solar Tiller

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**Abstract:-** Agriculture is very important for Indian economy. India being developing nation, the technology in agricultural sector has importance to improve productivity in this sector. The Rotary Tiller is a useful machine in farm land cleaning after cutting crops having very close distance between the plants like vegetable crops, cotton, cultivation of paddy etc. A Rotary tiller is a type of motorized cultivating equipment that breaks the soil with the help of rotary blades. It is used for removing weeds (waste plants) in agricultural land before and after planting seeds. The present SOLAR TILLER project is developed by the integrating of the Electric Hub motor to rotate blades and motor is powered by solar photo voltaic cells and allows farmers to do farming with less efforts and at almost zero running and maintenance costs with no pollution.

**Key-words:-** Solar tiller, electric Hub motor, eco friendly, controller, battery, accelerator.

### 1 Introduction

Agriculture is very important for Indian economy. The tiller and weeder is a machine which are used for cleaning of top surface of farm land at close distance crops plants like groundnuts, sugarcane, soya bin crops, cultivation of paddy.

The present solar tiller uses an electric motor running with the help of batteries. These batteries are charged by solar panels during day time. During night time it can be charged with the domestic power. Accelerator is provided to operate DC motor with which blades are rotated to pulverize the soil or to remove weeds from agricultural lands.

Solar panels convert the solar energy in to electricity and it is stored in batteries and this stored energy is transferred to DC motor to get mechanical output, As motor rotates the blades are rotated by means of sprocket-chain mechanism between blades and motor powered by solar energy by using solar panels. The solar energy from sun is converted to electricity through solar panels and it is stored in batteries and then motor converts this electrical energy into mechanical energy providing useful output for tilling the agricultural land.

### 2 Solar Tiller

The current design of solar tiller is a replacement of powered tiller. Powered tiller has so many draw backs, to obviate such difficulties, the solar panels are used. Lead batteries and tiller blade are used to operate the solar tiller . At the day time solar energy is used to charge batteries, but on cloudy days or during night time it uses domestic power to charge the batteries.

### 2.1 Principle

Law of conservation of energy states that energy cannot be destroyed or created but it can be changed from one form to another.

### 2.2 Methodology

Solar energy is converted into electrical energy and then this electrical energy is converted into mechanical energy. The order of energy conversion is shown in figure 1.



**Figure 1:** Conversion of Solar energy into mechanical energy

### 2.3 Description

The current solar tiller is very simple design. BLDC hub motor is used for running the tiller blades. It is run with the help of DC Electric motor which runs with the current supplied by the DC batteries which can be charged with the help of solar panels and domestic power supply. Figure 2 shows views of frame.



**Figure 2:** Views of the frame

## 2.4 Objectives

- To reduce the efforts of farmer in tilling the land and removing weeds.
- To lower the operating costs on tilling the land and on removing weeds.
- To successful usage of solar energy in farming machineries.
- To reduce pollution in farming fields.
- To save crude oil and to save the energy to the nation.

## 3 Methodology

### 3.1 List of Components Used

- Brushless dc hub motor: 500watts (48vdc)
- Batteries (4 in number): each 12V,24 AH
- Solar panels (4 panels): 80watts
- Rotary blades: 2 sets ,8 blades
- Motor controller: 500 watts
- Charge controller: 48V 20 AH
- Angle iron: 30 kg
- 25mm rods: size of 70cm, 60cm,30cm
- Pedestal bearings(6 no.): 25mm size
- Bicycle handle: one piece
- Sprockets 4 with chain: 21,42,48 & 60 teeth respectively
- Wheels (3): 30cm diameter
- Nuts and bolts of different dimensions are used to fit the assembly of chasis and galvanized sheets to cover the body.

### 3.2 BLDC Hub Motor

BLDC hub motors have been widely used in bicycles and scooters and are now expanding into small electric transport carts and small vehicles. The hub motors discussed here are direct-drive motors with no gearbox. The direct-drive motor will be a low-speed motor. Without the mechanical advantage of gearing, the motor size is limited by the tyre ID. BLDC Hub motor used in the present tiller and circuit are shown in Figure 3a&b.



Figure 3(a): BLDC Hub motor

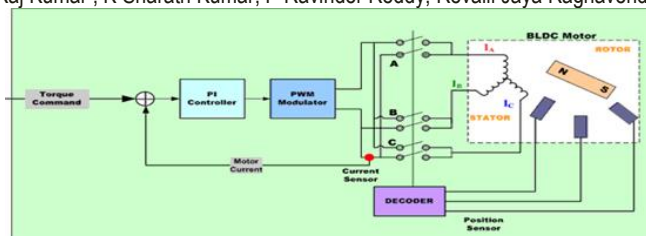


Figure 3(b): Circuit diagram of hub motor connection

Hero-electric Bike Hub motor is used and mounted at rear wheel of bike. It has 48V 10amps specification which requires 48V batteries. It is a outer rotation motor, its top speed is 40km/hr.

### Lead Acid batteries

Valve Regulated Lead Acid (VRLA) Batteries [1] are low maintenance sealed lead-acid batteries. They limit inflow and outflow of gas to the cell - thus the term "valve regulated". VRLA batteries are unique due to the fact that they contain a "starved" electrolyte (acid), which is absorbed or immobilized in a separator.

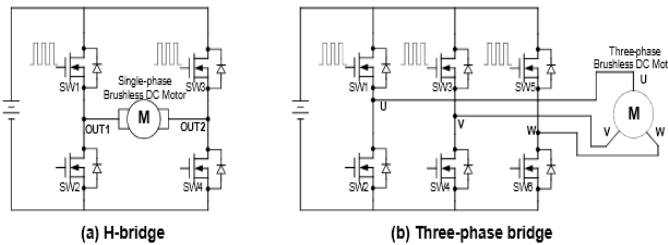
Batteries are connected from terminal to terminal in a way that positive (+) terminal of one battery is connected with negative (-) terminal of other battery and negative terminal (-) of one battery is connected with positive terminal (+) of other battery as shown in Figure 4.



Figure 4: Batteries connected in series

### 3.3 Brushless DC Motor Control

Brushless DC motors use electric switches to realize current commutation, and thus continuously rotate the motor. These electric switches are usually connected in an H-bridge structure for a single-phase BLDC motor, and a three-phase bridge structure for a three-phase BLDC motor shown in Figure . Usually the high-side switches are controlled using pulse-width modulation (PWM), which converts a DC voltage into a modulated voltage, which limits the startup current, control speed and torque. Generally, raising the switching frequency increases PWM losses, though lowering the switching frequency limits. The connection circuit of DC motor controller and electric drive is shown in Figure 5.



**Figure 5:** DC motor controller and electric driver circuit

### 3.4 Full Twist Throttle

Full twist throttles are the largest type of Ebike throttle and require the whole hand to operate. The full twist throttle takes up the entire end of the handlebar, completely replacing whatever grip would originally be on the end of handlebar. To operate it, the rider simply grabs a handful of throttle and twist it back towards himself.

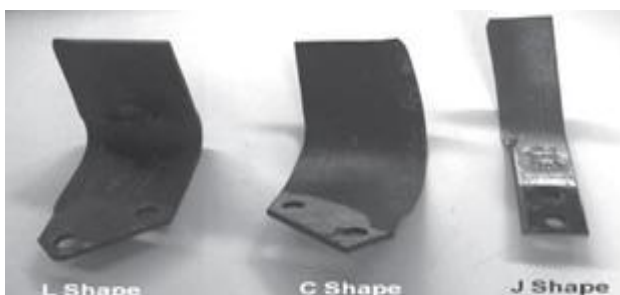
Throttle used is a 3-Pin Molex connector which is connected to motor controller power from batteries is transferred and used to operate at different level of speeds. The full twist throttle used is shown in Figure 6.



**Figure 6:** Full twist throttle

### Tiller Blades

In tiller blades are attached to a flange mounted on a rotating shaft usually by nuts & bolts shown in Figure. 7a & 7b Commonly three types of blade geometries are used as blades for weeders and tillers; namely: 1) L-shaped Blades 2) C-Shaped Blades 3) J- Shaped Blade



**Figure 7(a):** Tiller blades

L shaped blade design is selected as base for geometry generation.



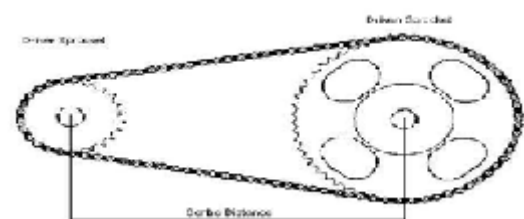
**Figure 7(b):** Nuts and bolts assembly

Most soils found in India such as Black Cotton soil, Alluvial soil, Lignite or red soil, etc. are classified on the basis of their basic content such as sand base, loam base or clay base.

### Sprocket and chain mechanism

Chain drives maintain a positive speed ratio between driving and driven components, so tension on the slack side is considered as zero. These are used for the transmission of power in cycles, motor vehicles, agricultural machinery, road rollers etc. The chains are made with the help of number of rigid links which are hinged together by pin joints in order to provide the necessary flexibility for wrapping round the driving and driven wheels. These wheels have projecting teeth of special profile and fit into the corresponding recesses in the links of the chain as shown in Figure 8. The toothed wheels are known as sprocket wheels or simply sprockets [3].

Roller chain consists of two rows of outer and inner plates. A Pin is inserted in the holes of the inner pair of links and is riveted to the outer pair of links as shown in Figure 8. Each bush is surrounded by a roller.



**Figure 8:** Sprocket and roller chain connected assembly

### Solar panels

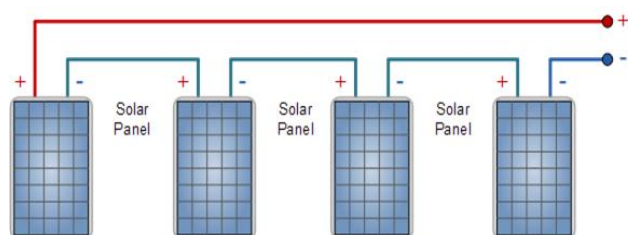
Energy conversion devices are used to convert solar energy (sunlight) into electricity by the use of the photovoltaic effect are called solar cells. In general, a solar cell that includes the capacity to capture both solar and non-solar sources of light (such as photons from incandescent bulbs) is termed a photovoltaic cell. The basic material used for [2] production of the solar cells is silicon and is shown in Figure 9a.



**Figure 9(a):** Solar panels

### Connecting Solar Panels in Series

The first method for connecting solar panels together is what's known as "Series Wiring". Connecting solar panels together in series is used to increase the total system voltage. Solar panels in series are generally used when charge controller requires 24 volts or more. The solar panels are connected in series i.e. the positive terminal is connected to the negative terminal so that in the last one positive and one negative terminal is left as shown in Figure 9b. [5], [6].



**Figure 9(b):** Solar panels in series connection

### Solar charge controller

The solar charge controller is installed between the solar panel array and the batteries. The job is to regulate the voltage and current coming from the solar panels to the batteries, preventing the batteries from current coming from the solar panels to the batteries, preventing the batteries from being overcharged and preventing backflow of current to the solar panel array. If the panels are connected directly to the batteries, it will severely reduce life and efficiency.[4]

### Assembly of all parts

Angle rod is used to make the frame of the solar tiller. They are cut into length of 120 and breath of 60centimeters. They are joined with the help of arc welding. As shown in Figure10.



**Figure 10:** Rectangular frame

To fix tyres under the frame, angle rod was made in to the shape as shown in Figure 10. This was done by tapping, bending and cutting of angle rods. The bright rod shaft of 90cm length was selected and inserted in to the two rear tyres and locked both the ends. The bright rod along with two tires are fixed to the frame with the help of 25mm pedestal bearings by nut and bolt system as shown in Figure 11.



**Figure 11:** Pedestal bearing

The front tyre was fixed to the frame by attaching hub to the front face of the frame.

Hub motor fixed on to the frame with the help of two rectangular supports so that the shafts on motor is made to fix and have complete rotation of motor. The rectangular supports are made with the help of angle rods which are tapped, bent, and made to cut with the help of cutter. The two identical rectangular supports are welded to the frame exactly above the shaft of rear wheels on to the frame as shown in Figure 10.

Sprocket of 42 teeth was selected and it is welded on the round disc having diameter slightly greater than brake hub of motor. The round disc along with sprocket is made a force fit in to the brake hub of motor. To avoid slippage of the brake hub and round disc containing sprocket is prevented by nut and bolt at different places on the circumferences by drilling holes on both as shown in Figure 10.

All the components are fixed with help of screws and bolts and nuts the complete frame is welded with help of arc welding as shown in the Figure 10.

Tiller blades are fix to the rear end of the solar tiller and even handle is fixed for the turning the solar tiller into required direction.

### Working

Solar tiller batteries are charged with help of solar energy as well as domestic power supply and the power is stored into VRLA batteries. Solar panels are connected in series and then terminals are connected to solar charge controller. From solar charge controller the positive and negative terminals are connected to the batteries. These batteries are connected in series such that they give 48volts 24amph. Batteries terminals are connected to the hub motor controller and to which hub motor and full twist throttle is connected.

With the help of the key the solar tiller is started with the help of the throttle the speed of the hub motor is controlled. When the lever is lifted upward direction the tiller blades will move inside the soil, its lever is locked with bolt and nut so that its position does not get disturbed when the solar tiller is running. With the help of the chain and sprocket mechanism the hub motor transfers its energy to tiller blades to plough the land. Complete assembly view of solar tiller is shown on Figure 12.

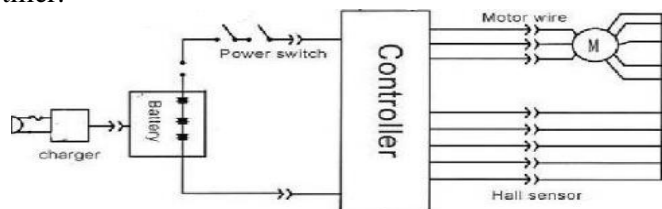


Side view front views

**Figure 12:** Assembly view of solar tiller

### Circuit connection

Figure 13 shows basic connection diagram of solar tiller.



**Figure 13:** Circuit connection

### Advantages

- Simple in design
- Easy to operate

- Easy to maintain
- Cheap in cost
- Pollution free
- Eco-friendly
- User friendly
- It has no running cost.
- Solar radiations are easily available in rural area
- It uses renewable energy for running

### 4 Conclusion

- Today in the world fuel prices rise day by day and the pollution also.
- To control the pollution and to save the petroleum product and bio product this project is designed and developed.
- This system requires less initial investment and it gives the energy output for life time with low maintenance cost.
- The present solar tiller reduces the maintenance costs and helps Indian farmers to cultivate with minimum cost. Solar power which is abundantly available in nature is used to run tiller, As it is pollution free and eco friendly.

### 5 Future Scope

- The output power from motor can be used to run small domestic electrical equipment and appliances.
- It can be used to operate water pumps in agricultural fields.
- It can be used as pesticide sprayers by attaching pump to it.

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