International Journal of Scientific Research in Engineering and Management (IJSREM)
Volume: 08 Issue: 12 | Dec - 2024 SJIF Rating: 8.448 ISSN: 2582-3930

DESIGN AND FABRICATION OF SOLAR POWERED PESTICIDE SPRAYER

Milind Solanki[1], Vicky Shinde[2], Nilay Shirsat[3], Shravan Venugopal[4]

[1,2,3,4] *Department of Mechanical Engineering, RGIT, University of Mumbai, Mumbai, Maharashtra, India*

Abstract - Protecting crops against weeds, insect pest, and germ is becoming a biggest challenge for the farmers. To overcome this issue. chemicals (pesticides) are applied to crops For this purpose a pesticide sprayer are used. Sprayers are mechanical devices that are specifically designed to spray Chemicals quickly and easily. A sprayer of this type is a great way to use solar energy. Solar based pesticides sprayer pump is one of the improved version of petrol engine pesticide sprayer pump and hand pump sprayer. It is vastly used in the agriculture field & also used for many purposes. This is having more advantages over petrol engine sprayer pump. It uses the solar power to run the motor. So, it is a pollution free pump compared to petrol engine sprayer pump. The solar panels make up most (up to 80%) of the systems cost. The solar sprayer has many advantages. Besides reducing the cost of spraying, there is a saving on fuel/petrol. Also Reduces man effects in case of hand sprayer. The solar sprayer maintenance is simple. The operation of solar powered pumps is more economical mainly due to the lower operation and maintenance costs and has less environmental impact. Solar pumps are useful where grid electricity is unavailable and alternative sources. The farmer can do the spraying operation by himself without engaging labour, thus increasing spraying efficiency. In this context, we have proposed an innovative sprayer model for optimized spray applications with minimum losses and cost. The proposed working model of automated pesticide sprayer was designed, fabricated and analysed for performance tests. This sprayer operates on electrical power supplied by solar panel with battery of designed capacity. An added advantage of this automated pesticide sprayer is that it does not have any impact as far as farmers health is concerned and also it is free from greenhouse gas emissions. It has also been proven itself to be an efficient, reliable and economical one to spray pesticides for agriculture applications.

***Key Words*:** Pesticides, Solar Energy, Pollution free, Fuel saving, Automated Sprayer, Greenhouse gas emissions.

1. INTRODUCTION

As India is an agricultural country various types of crops and plants are available in different parts of India. In India due to sudden climatic changes farmer are facing huge problems regarding their development of crops. Spraying of pesticides is an important task in agriculture for protecting the crops from insects. Farmers mainly use Hand operated or fuel operated spray pump for this task. This conventional sprayer causes user fatigue due to excessive bulky and heavy construction. This motivated us to design and fabricate a model that is basically solar sprayer. The basic principle of pesticide sprayer is to appropriately target the required place which enhances the effective usage of agricultural chemicals. To favour so certain factors which matters a lot are size of the droplet, type of sprayer nozzle, target timing, drift, proper use of sprayers, evaporation of droplet, weather condition, volatilization, distance and height of spraying. The elimination of fuel will make our spraying system eco-friendly. So, with this background, we are trying to design and construct a solar powered pesticide sprayer. Now days there are non-conventional energy sources are widely used. The energy which is available from the sun is in Nature at free of cost. In India solar Energy is available around 8 months in year .so it can be used in spraying operation. Solar pesticide sprayer can give less tariff or price in effective spraying. Solar energy is absorbed by the solar Panel which contains photovoltaic cells. The conversion of the solar energy into electrical energy is done by these photovoltaic cells. This converted energy utilizes to store the voltage in the DC Battery and that battery further used for driving the spray Pump. Solar spray is the ultimate cost-effective solution at the locations where spraying is required. This solar-powered spray pump system uses solar energy as source. Solar energy is first used to charge a storage battery. The solar energy stored in the battery is utilized to operate motor which functions as pump. And our paper or main motive is to deals with the constant discharge of pesticide, compress air control system, solar power, battery charging, monitoring as well as power controlling techniques. As far as controlling is concerned, it includes the

parameters such as pressure, pesticide level, battery voltage, current, solar cell and discharge condition. In this paper we are trying to make unique equipment for cultivation users. So, in this paper we have committed to do something unique and useful equipment with nonconventional source technique. In this project we made three wheeled frame which is connected to motor and move in the presence of solar energy which also simultaneously spray with same solar energy.

2. PROJECT LAYOUT

Before starting the fabrication task, the first step was to know what is the aim and the objectives of this project. So, gaining knowledge and information was necessary to get more idea about the project. To obtain this literature review was done. After referring different papers, the next step is to know what is lacking in different or similar projects. Some areas the other projects were weight, speed, spraying distance etc. After doing the gap analysis list of components was created for the fabrication of the project.

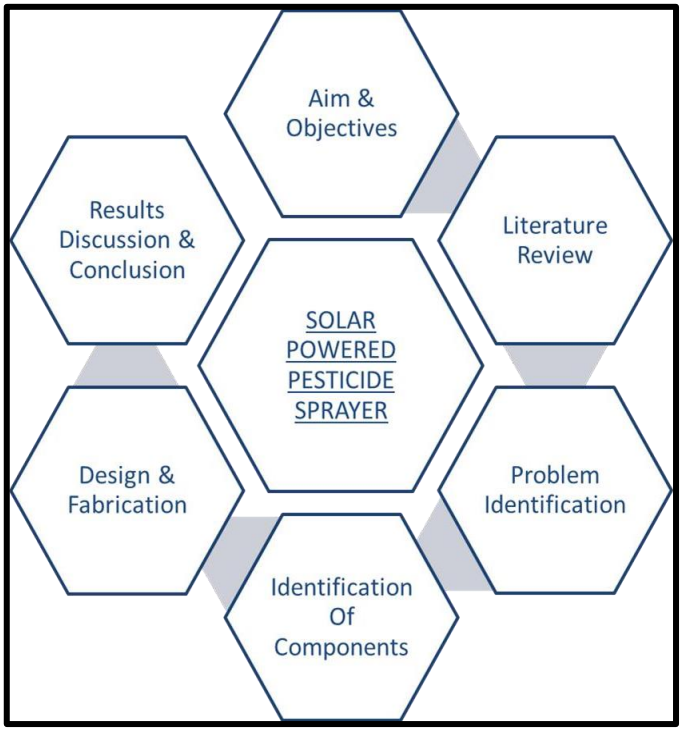

Figure 1 Project Layout

Design calculation for the selection of motor was done to get the required RPM for the project and also a motor that consumes less power so, that the other electrical components can sufficiently power. After calculating and finalizing the desired weight and RPM the fabrication of frame was done. For the fabrication of frame, a cycle frame of 10-12 years old cycle was purchased from scrap. Frame rework was done by using tungsten arc welding, gas welding and cutting operation were carried out to obtain the required dimensions. After the fabrication of frame, the next step was to make a solar panel frame that is to be mounted on the frame. So Cast steel rectangular plates was used to create the solar panel frame and was mounted on the frame. After the fabrication of frame and the solar panel frame mounting of the motor was the next task.

3. WORKING SCHEMATIC OF THE PESTICIDE SPRAYER

The system consists of Solar panel, solar panel controller, battery, pump and sprayer. The solar panel delivers an output in the order of 12 volts and 50 Watts power to the charging unit. The charging unit is used to strengthen the signal from the solar panel. The charging unit delivers the signal in which battery charges if solar panel controller unit is not used and direct connection from solar panel to the battery is made the health of battery gets affected and it does not do charge. Here fertilizer is stored in tank. When the sun rays are incident or striking on the solar energy will be generated which further gets converted into electricity through the solar cells and gets stored in the battery. By the electric power in the battery the pump operates and therefore fertilizers from the tank are sprayed out through the nozzles. The motor will help to driven the pesticide sprayer to move forward. There is no maintenance cost and operating cost as it is using solar energy and no pollution is generated. So, the sprayer which will be used is a knapsack sprayer (flat fan nozzle), it provides proper spraying distance as compare to another spraying nozzle. And where as in non-sunny days when there is less availability of light, at that time we can utilise charge from the battery and use it to spray pesticides to the herbs and plants. This nozzle is suitable for spraying Chillies, Cauliflower, Cabbage etc. which has an average height of 40-45 mm.

4. DESIGN CALCULATION

4.1 Motor Selection

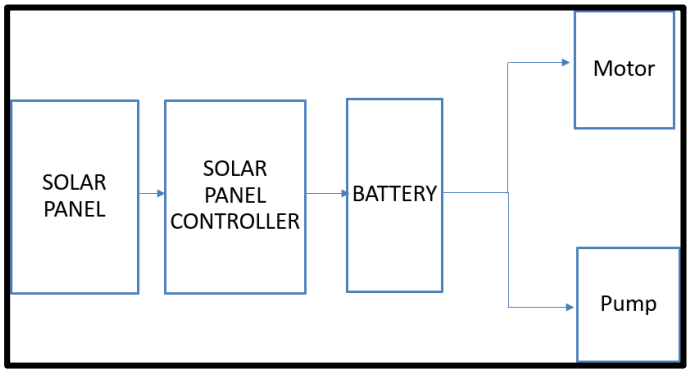

Figure 2 Signal flow between different components of the pesticide sprayer

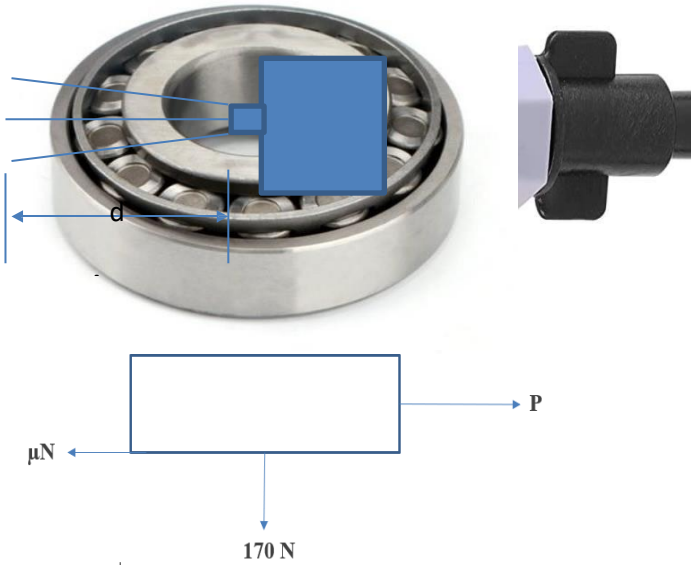

Figure 3 Force diagram

Total weight of the project is calculated to be assumed 170N. g=10 m/s^2

Motor speed assumed 300 rpm Motor selection-

Therefore f= 170x0.1=17N

This is the required force which will drag our model Taking 300 rpm gear motor which is suitable for the model

Calculating Torque: -

T=$f \times v$

=170 x 0.1 =17 N-m

Calculating power (P): -

P=$2\pi NT/60$ = (2×3.14×300×17)/60000 = 0.53 KW

Hence selecting rectangular gear motor having 300 rpm with 5A we have used two motors to obtain more speed.

4.2 Nozzle Calculation

Nozzle selected knapsack sprayer

Diameter of the tube= 9mm

Diameter of nozzle spray= 1mm Quantity of the tank= 5 litres

Area covered by sprayer with 1 litre(A) = Capacity of the tank(c) x spraying distance or discharge(d) Therefore, A=c x d

To find spraying distance

d= 50 cm, c= 5 litres

A= 50 x 5 = 250 m^2

Plants & vegetables like Cabbage, Tomato, Chilli's has an average plant height of 40-50cm. This nozzle sprayer has a spraying height of 40-60 cm.

Figure 4 Nozzle

Figure 5 Roller Bearing

4.3 Bearing Selection

Inner diameter = 20 mm

Load=170 N

Life of bearing (Lh)= 35000hrs

Lmr = $Lh \times 60 \times N$ 106

Lmr = 35000 ×60 ×300 106 = 630 mr

Pe = $(V \times x \times Fr + Y \times Fa) \times Kt$

Pe= 18.7 kgf

Dynamic capacity $L10$ = (/Pe) ^{K} = 129.31 kg

Selecting roller bearing having inner diameter of 20 mm and outer diameter 42 mm.

5. LIST OF COMPONENTS

- Frame
- Motor
- Motor Controller
- Solar Panel
- Solar Panel Controller
- Control Switches
- Wheels
- Water Pumps
- Pipes
- Sprayer (Flat Fan Nozzle)
- Tank
- Shaft
- Bolts & Nuts
- Nozzle
- Bearings
- Battery

5.1 Frame

Steel, Aluminium Alloy and Carbon Are the most popular material used for manufacturing in the bicycle frame. Steel has been used by frame builders for over a century. Many types of steel tubing are available and the material is easy to bend and shape.

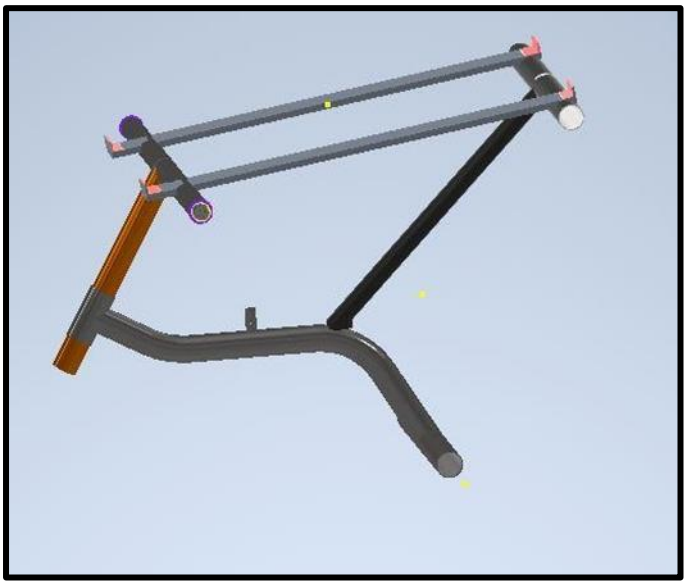

Figure 7 Pesticide Sprayer frame designed in Autodesk Inventor

In this project a scrap cycle was chosen (10-12 years old cycle). The frame was reworked to make it according to the design sheet. Gas welding operation was carried out as the frame was made of steel.

5.2 Motor

Type of Motor- Rectangular Gear Motor

Specification: It is 12V Gear Motor which runs on 300RPM Shaft Diameter (std) – 8 mm Shaft Length (generally) – 27 mm Operating volt - 6- 24 V

Figure 6 Frame Fabricated

Figure 8 Rectangular Gear Motor

Definition: A rectangular gear motor is a high torque gear motor which is widely used in e-carts. Each motor can take a load of 30 kg. It consumes about 10.15 V of current from the battery. To control the speed of the motor an external motor speed controller/ regulator is required which produce 5 Amps.

5.3 Solar Panel

We are using a solar panel which having Power: 50 Watts.

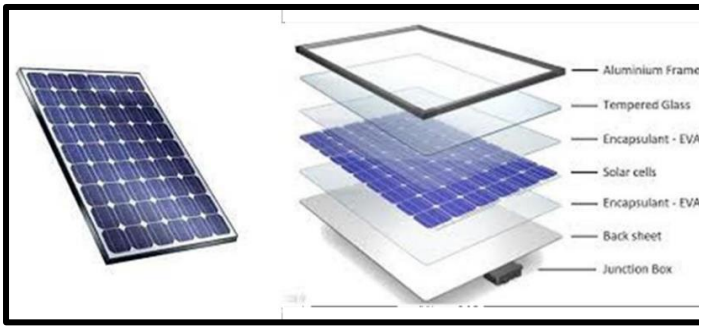

Figure 9 (left) Solar Panel (right) Exploded View of the internal components of the Solar Panel

Specs-

Voltage: 12V

Size: 65×55 cm

Number of cells: 32 to 36

Output Voltage: 18 V-24V

Solar Panel- A solar cell (also known as a photovoltaic cell or PV cell) is defined as an electrical device that converts light energy into electrical energy through the photovoltaic effect. A solar cell is basically a p-n junction diode. Solar cells are a form of photoelectric cell, defined as a device whose electrical characteristics – such as current, voltage, or resistance – vary when exposed to light.

Individual solar cells can be combined to form modules commonly known as solar panels. The common single junction silicon solar cell can produce a maximum open-circuit voltage of approximately 0.5 to 0.6 volts. By itself this isn't much – but remember these solar cells are tiny. When combined into a large solar panel, considerable amounts of renewable energy can be generated.

Definition: Solar panels are those devices which are used to absorb the sun's rays and convert them into electricity or heat. ... Thus, it may also be described as a set of photovoltaic modules, mounted on a structure supporting it. A photovoltaic (PV) module is a packaged and connected assembly of 6×10 solar cells.

5.3.1 Working of Solar Cell

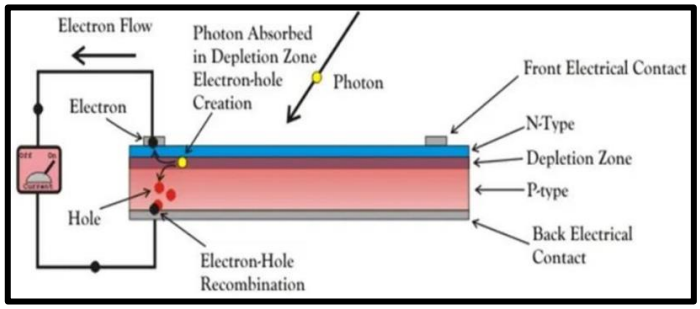

Figure 10 Solar Cell

When light reaches the p-n junction, the light photons can easily enter in the junction, through very thin ptype layer. The light energy, in the form of photons, supplies sufficient energy to the junction to create a number of electron-hole pairs. The incident light breaks the thermal equilibrium condition of the junction. The free electrons in the depletion region can quickly come to the n-type side of the junction.

Similarly, the holes in the depletion can quickly come to the p-type side of the junction. Once, the newly created free electrons come to the n-type side, cannot further cross the junction because of barrier potential of the junction.

Similarly, the newly created holes once come to the p-type side cannot further cross the junction became of same barrier potential of the junction. As the concentration of electrons becomes higher in one side, i.e., ntype side of the junction and concentration of holes becomes more in another side, i.e., the p-type side of the junction, the p-n junction will behave like a small battery cell. A voltage is set up which is known as photo voltage.

Why we selected polycrystalline solar panel?

• Polycrystalline solar panels cost less and have a simpler manufacturing process.

• Polycrystalline solar panels tend to have a lower heat tolerance.

• There is less wastage of silicon while manufacturing these panels.

5.4 Solar Panel Controller

Figure 11 Solar Panel Controller

Panel Suitable 10-100 Watts

Power 12-24 V

Selecting an efficient and properly designed charge controller is key to the longevity and efficiency of your entire battery-based photovoltaic (PV) system. By optimizing the power coming in from your solar modules, you will get that much closer to offset your use of traditional grid power or another source of energy. In addition, you will be protecting your battery bank and thereby you protect yourself from any unforeseen and needless replacement costs. Your solar charge controller is an item well worth investing in and researching as you design your system. Solar charge controllers are rated and sized by the solar module array current and system voltage. Most common are 12, 24, and 48-volt controllers. Amperage ratings normally run from 1 amp to 80 amps, voltages from 6-600 volts.

5.5 Control Switches

Figure 12 Toggle Switch

We are using this control switches to control the spraying the pesticides vast inventory of cam switches, disconnect switches, contactors, push buttons and terminal blocks. Our rotary cam switches and our control panels are. It is the normal switches used for the controlling system.

5.6 Wheels

Figure 13 Cycle Wheel

It is the normal cycle wheel we are using in the project. We will select the wheels according to the project based so that it can take the load and move freely.

5.7 Water Pumps

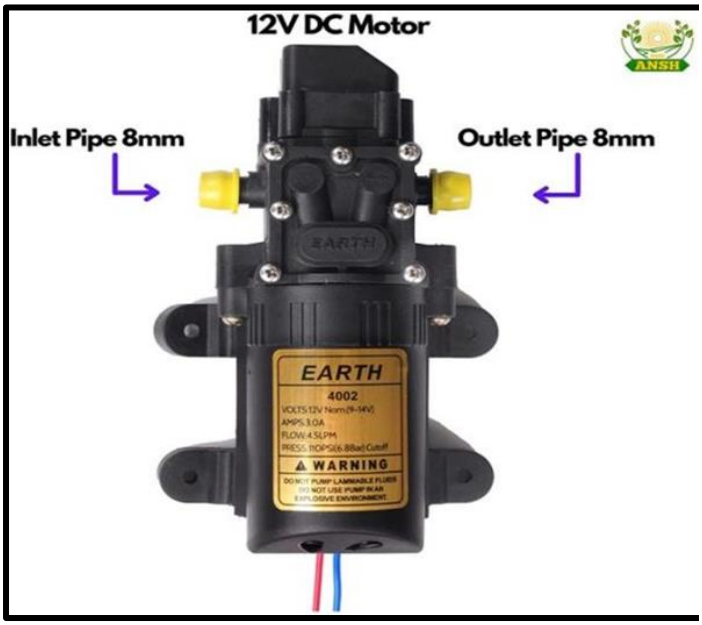

Figure 14 Water Pump

It is the 12V water high pressure water pump. Its flow rate is 4.5 liters per minute solar powered design is energy efficient for remote, inaccessible, or off-grid locations. Rest easy with a reliable solar water pump that effectively makes water usable and convenient

5.8 Sprayer

Figure 15 Sprayer

The plastic flat fan nozzle produces a flat fan spray pattern with an even and uniform distribution across the spray width. The flat fan nozzle is a one-piece construction with a male threaded connection and hex body for easy installation. Crops like Cauliflower, Chillies, Cabbage etc Flat Fan Spray Nozzle is recommended as it provides uniform spraying of pesticide to each crop. And the spraying distance can be adjusted from 20-60 mm and the spraying height can be adjusted up to 40 mm.

5.9 Bearings

Figure 16 Bearings

Two bearing having an inner diameter of 20 mm and outer diameter 42 mm was used. The two identical bearings are connected to the plates which was used for placing the motors. The type of bearing used were roller bearing. Roller bearings also known as rolling-element bearings are similar to ball bearings in that they are designed to carry a load while minimizing friction.

5.10 Lead acid Battery

Figure 17 12 V Lead Acid Battery

A battery can be defined as an electrochemical device which can be charged with an electric current and discharged whenever required. Batteries are usually devices that are made up of multiple electrochemical cells that are connected to external inputs and outputs.

6. ADVANTAGES & DISADVANTAGES

Advantages

- Solar pesticide pumping is clean and efficient.
- Solar power provides clean energy
- Solar-powered pesticide systems take very little maintenance because they only have a few moving parts. They have long life---usually 20 to 40 years and solar pesticide systems never run out of fuel as long as the sun is shining.
- Solar Powered Pesticide Sprayer can also be used during the non -availability of sunlight.

Disadvantages

- Proper steering system is required.
- Special tyres are required for different agricultural lands.
- Lower output in cloudy weather
- Relatively high initial cost

7. FUTURE SCOPE

- Adjustable sprayer height
- Remote control
- Wheels according to the muddy conditions
- Steering system

8. CONCLUSION

- Increased speed, efficiency, more spraying distance and lighter in weight is achieved.
- The sprayer and the motor are successfully working with a single solar power output.
- The output of the pumping rate changes with the atmospheric conditions such as temperature, density of liquid being sprayed

9. REFERENCES

[1] M. Kamaraj et al. (2017) "Design and Fabrication of Multipurpose farming tools equipped mobility cycle", International Journal of Innovative Research in Advanced Engineering, Vol 4, Issue 5.

[2] Malatesh, D. et al. (2017) "Solar powered sprayer for agricultural and domestic purpose", International Journal of Research in Engineering and Science, Vol 5, Issue 6.

[3] Bhalerao, M. et al. "Development and fabrication of smart spray pump".

[4] R. Joshua. et al. (2010) "Solar Sprayer an Agriculture Implement", International Journal of the Sustainable Agriculture 2(1):16-19

[5] Ashutosh Mishra et al. (2019) "Development of Solar Operated Sprayer for Small Scale Farmers", International Journal of Current Microbiology and Applied Sciences ISSN: 2319-7706 Vol 8 (2019)

[6](Solarenergyhub,2021) https://solarenergyhub.com/types-of-solar-batteries/

[7] Sprayer. (2021, 10 05). Retrieved from Wikipedia: https://en.wikipedia.org/wiki/Sprayer#Agricultural_sprayers