Performance Analysis of Modified Agricultural Spray Pump

Ankush Prakash Borkar[1], Dr.Ravindra. N. Dehankar[2]
[1]*Student Mechanical Engineering Design, Anjuman College of Engineering, Nagpur University*
[2]*Assistant Professor Department of Mechanical Engineering, Anjuman College Of Engineering, Nagpur University*

***Abstract*— India is an agriculture-based country, with 70% of people relying on agricultural outcomes. However, as the population grows, the farms are dispersed among families, so Indian farmers only own two acres on average. Farmers are also very poor economically, so they cannot afford expensive equipment and use traditional cultivation methods. In this project, we will look at a photovoltaic pesticide sprayer with wheels. This type of atomizer is a great way to quickly and easily cover large areas such as lawns. Solar sprays are the best cost-effective solution for where you need a spray. This study seeks to provide a comprehensive solution to the future energy needs of agriculture. Not sprayed all year round. As a result, the same PV (photovoltaic) systems used in solar sprays can be used to power other farm operations such as pumps and lighting. Rising prices and the availability of traditional electricity or fuel during peak hours in remote areas are two variables that influence their adoption. Therefore, there is a need to focus on the design and development of self-contained renewable energy sources that can provide consistent power and meet the energy needs of farmers far from the farm.**

***Index Terms:* Agricultural Sprayers, Agro-spray, Conventional Energy, knapsack sprayers, Power Sprayers, Solar Power.**

1.INTRODUCTION

Pesticide spraying is an important work in agriculture to protect crops from insects. Farmers mainly use manual or fuel-powered spray pumps for this work. Because of its bulky and heavy build, this typical sprayer creates user fatigue. This prompted us to design and produce a model that is essentially a solar sprayer in our design, where we were able to eliminate the rear mounting of the sprayer. Convenient, it is not good for farmers' health while spraying. In this way, we can reduce the level of user fatigue. The fuel injection pump engine will be eliminated, which will reduce vibration and noise. Eliminating fuel will make our injection system environmentally friendly. So with this background, we are trying to design and build a solar-powered spray pump system.

Today, other energy sources are commonly used. The energy available from the sun is natural in nature. In India, solar energy is supplied about 8 months a year. Therefore it can be used for spraying. Solar insecticide sprayers can offer a lower or lower price point for effective spraying. Solar energy is absorbed bysolar panels containing photovoltaic cells. The conversion of light energy into electrical energy is performed by these cells.

This converted energy is used to store voltage in a DC battery, which also powers the spray pump. Solar sprays are the best cost-effective solution for where you need a spray. This PV spray pump system uses solar energy as an energy source. First, it uses solar energy to charge the accumulator. The solar energy stored in the battery is used to power the motor that acts as a pump. As the title of the paper suggests, it covers the continuous distribution of pesticides, compressed air control, solar power, battery charging, monitoring, timers, and non-conventional energy control technologies. Parameters such as pressure, amount of pesticide, battery voltage, current, solar cell, and discharge status belong to the control.

In this article, we are trying to create a unique gadget for growing users. Pesticide sprays play an important role, especially in the melding process, due to the toxicity of chemicals. Therefore, this document promises to do something unique and useful in non-traditional source engineering. It also reduces the weight of your solar spray compared to diesel spray.

2. CLASSIFICATION OF SPRAYING SYSTEMS

Different types of sprayers can be utilized in India depending on the growth of different types of crops such as fallow:

1) Hand-operated sprayer.
2) Engine-operated sprayer/fuel-operated sprayer.
3) Electric motor pump sprayer.

1) Hand-operated sprayer

Because the hand-powered sprayer is operated by hand, it causes discomfort during spraying.

2) Engine-operated sprayer/fuel-operated sprayer

The engine-driven sprayer, as we all know, runs on fuel. Petrol is a costly fuel, thus it is not a wise investment for farmers.

3) Electric motor pump sprayer

Electricity is utilized to charge the battery in the electric motor pump sprayer. Although the pump can be driven according to battery charging in this manner, there are several disadvantages to the current sprayer.

For example,

1) A hand-operated sprayer cannot be used indefinitely. We can conclude that it cannot be utilized for an extended period of time.

2) Because engine-driven sprayers can run on gasoline, they are not suitable for every farmer.

3) Rural areas can house up to 70% of the population. Electricity is in short supply in rural places. As a result, spraying with an electric motor pump is not conceivable.

3. PROBLEM IDENTIFICATION

In India, seventy-threepercent of the population is directly or indirectly dependent upon farming. Thus India is currently an associate agricultural primarily based company. However, currently, farmers face various issues.

A. Pests: Farmer's productivity is vulnerable to pests. Pests are a significant threat to food production. Global climate change produces hotter temperatures and will increase CO2 gases, downfall, and drought that enhance malady, pests, and weeds. Higher data and underneath standing of pesterer behavior under completely different projected situations are needed to adapt and develop new technologies to retort to threats ensuing from global climate change.

B. Lack of Mechanization: In spite of the large-scale mechanization of agriculture in some elements of the country, most of the agricultural operations in larger elements are carried on by human hand victimization straightforward and traditional tools and implements like a wood plough, sickle, etc. this can be especially the case with tiny and marginal farmers. Because of poor mechanization and crude agricultural techniques, the farmers don't get an honest price for their manufacture. Strenuous efforts are being created to encourage the farmers to adopt technically advanced agricultural instrumentation.

C. Short offer of electricity: Rural areas face serious issues with the liableness of power offer. In a country like India, most of the folks in rural areas depend upon agriculture. They additionally face a tangle of erratic and random electricity offered in villages. Thanks to this, farmers need to build multiple visits to the farms at odd timings simply to show on the pumps.

D. Existing strategies - Ergonomically imperfect: Most of the prevailing spraying techniques are either terribly serious to use or incompletely mechanized which ends in downside regarding their health and condition. Hard-to-please efforts are being created to scale back the strain and fatigue caused throughout farming activities so as to hold out farm operations timely and to economize the agricultural production method.

4. OBJECTIVE

In this project, we want to create unique agricultural users' equipment. Due to the chemical's poisonous qualities, pesticide spray plays a crucial part in the formation process. Therefore, we pledged to create something special and valuable for this project using an unconventional source technique. Additionally, the unique solar sprayer is lighter than diesel sprayers.

The major goal is to use the naturally occurring solar energy for wheel-mounted spraying activities.

- To reduce the expense associated with spraying equipment.
- Reducing operational costs by adding more new mechanisms.
- To reduce labour expenses by improving spraying techniques.
- To use no electricity at all.
- Year-round uninterrupted use of the field for spraying.

5. BLOCK DIAGRAM

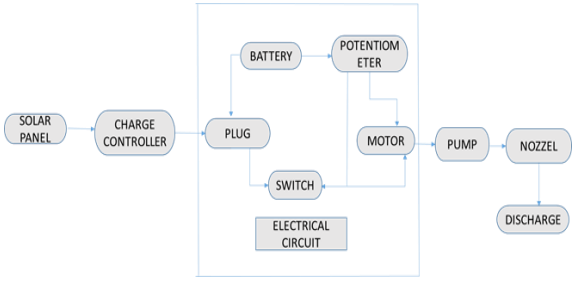

Fig.1. Block Diagram

6. WORKING PRINCIPLE

Among other things, it comes with a solar panel, a DC pump, a battery charging kit, a pesticide tank, and spray nozzles. Solar energy is used to power it. The solar energy is initially taken in by the solar panel. The photovoltaic cell transforms this solar energy into electrical energy. The battery is subsequently charged using this electricity. The battery will then be utilized to power the DC motor after that. A DC pump is driven by a DC motor and draws liquid into the liquid tank from its intake. The liquid will then be sprayed through a nozzle connected to the spray pipe from the DC motor outlet.

7. COMPONENTS OF A SOLAR-OPERATED PV SYSTEM FOR SPRAYING

Components Used: The output of the product is maximized by the component selection. The parts used in the following manner are as follows:

A. Tank

A water tank is a vessel used to store water. For a number of uses, such as drinking water, irrigated agriculture, fire control, agricultural farming (both plants and animals), chemical manufacture, food preparation, and other uses, water is stored in water tanks. Specifications provide information on a water tank's overall layout, construction components, and linings. A water tank can be made from a variety of materials, including plastics (polyethylene and polypropylene), fiberglass, concrete, stone, and steel (carbon or stainless steel, welded or bolted). Pesticide solution is kept in a tank in this location. 20 liters can fit in the tank. Additionally, it has a manual pump in the event that the battery is dead.

Fig 2.Tank

B. Nozzle

A nozzle is a tool used to control a fluid flow's direction and characteristics as it leaves (or enters) a pipe or enclosed space (especially to improve velocity). Nozzles are pipes or tubes having variable cross-sectional areas that are used to direct or modify fluid flow (liquid or gas). It is common practice to regulate the stream that emerges from nozzles by adjusting its flow rate, speed, direction, mass, form, and/or pressure. In a nozzle, fluid velocity rises at the expense of pressure energy.

Fig. 3 nozzle

C. Spray Gun

It is used to give direction to the pressured solution.

Fig 4. Spray Gun

D. Solar Panel

Solar energy may be used in a variety of ways to power appliances, making it arguably the cleanest and most dependable renewable energy source available today. Photons of light from the sun stimulate electrons in silicon cells in photovoltaic (PV) panels, transforming light into energy. A battery can then be charged using renewable energy using this electricity. By reducing electricity costs, these panels not only eventually pay for themselves but also reduce the amount of air pollution that utilities produce.

Fig 5.Solar panel

E. Charge controller

The charge controller controls how quickly electricity is added to the battery. Overcharging and overvoltage are therefore prevented. When the battery voltage rises above a certain high voltage level, it gradually stops charging the battery using the Pulse Width Modulation (PWM) approach, and it gradually resumes charging when the battery voltage drops below the safe level.

Fig 6.Charge controller

F. Dc Motor Pump

A Pump 12 V DC is a device that is attached to these lead acid batteries and transforms electrical energy into mechanical energy. Although the spraying force won't be as strong as when the battery is used, the solar panel can still be connected directly to the DC pump. The battery is hence absolutely necessary.

Fig 7. Dc Motor Pump

G. Battery

The positive terminal of a battery serves as the cathode and the negative terminal as the anode when it is supplying electricity. When connected to an external circuit, the negative terminal serves as the source of the electrons that flow and provide energy to an external device. To store the energy, a 12V battery is needed. The DC motor, which aids in air blowing and drives motor pumps, is powered by a battery. Additionally, it is occasionally used to charge mobile devices for workers who need to utilize LED lights at night.

Fig 8 Battery

H. Potentiometer

A three-terminal resistor with a sliding or revolving contact that creates a variable voltage divider is called a potentiometer**.**

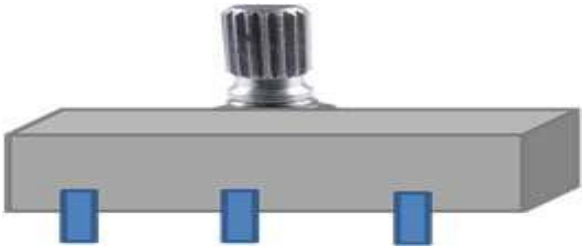

Fig 9. Potentiometer

I. Voltmeter

A voltmeter is an instrument used for measuring the electrical potential difference between two points in an Electric Circuit

Fig.10 Voltmeter

8. CALCULATION OF PROJECT

A. Selection of Spray Pump

Based on the spraying capacity, the spray pump is selected.

A centrifugal pump. 2.9 lit/min for liquid discharge.

3600 revs per minute. 350 W of power

B. Selection of Battery

The battery is chosen based on the working power of the pump.

Type: Lead-acid battery.

12 V at 8 A in current

Current = 2.4 A and voltage = 12 V when the circuit is short.

Power is calculated as Voltage x Current (12 x 2.4=28.8 W).

C. Selection of solar panel

Based on battery output power, solar panels are selected

Power = 20 W

500 mm x 22 mm x 340 mm in size

2.0 kg of weight

Short circuit current = 1.318

An Open circuit voltage = 21.6 V

Current in Use: 1.176 A

D. Battery charging time and current generated by the panel

- Knowing the maximum power (P) of the solar panel and the battery's voltage rating (V), as determined by the formula I = P/V, allowed for the calculation of the current produced by the solar panel (I). I = 20/12, which is 1.66 A.
- The ratio of the battery's ampere-hour (Ah) rating to the total current delivered by the solar panel was used to calculate the charging time (T). T = (amp-hour battery rating) / (total current consumed by the solar panel)

T = 8 / 1.66, which is 4.79 hours.

9. DESIGN OF SOLAR PESTICIDE SPRAYER

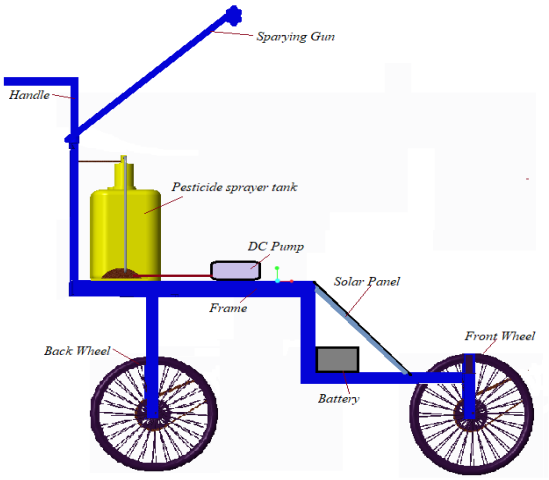

Fig 11. Basic Model of solar pesticide sprayer

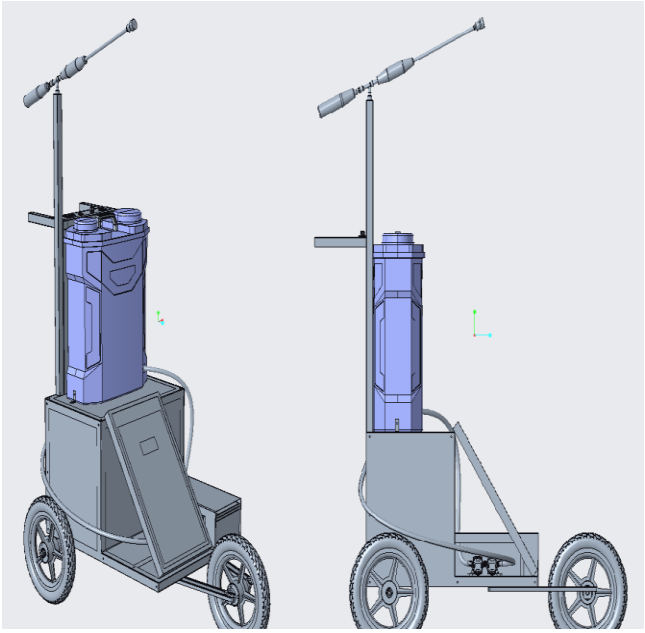

Fig.12. Design Model of solar pesticide sprayer

10. ADVANTAGE

A. The solar sprayer has many advantages:

- Besides reducing the cost of spraying,
- There is a saving on fuel/petrol for spray operations etc.
- Saving on transportation means less money spent on fuel.
- The solar sprayer maintenance is simple.
- Comparatively speaking to the fuel sprayer, there is less vibration.
- With the intention of lessening the operator's physical effort and enhancing spraying quality.
- Without hiring labour, the farmer can perform the spraying procedure, increasing spraying.
- It is a multipurpose machine.
- Easy to operate and user-friendly.
- Very less pollution than other models.
- It is portable
- Unit cost is very cheap.
- Maintenancescost is low.

B. The oldest and most significant occupation ever undertaken by humanity is farming, although in the majority of the world, it is still carried out in a traditional manner. Although farmers are adjusting to the changing times, much more has to be done. Therefore, one way through which formers can quickly and affordably form is the solar spray mechanism.

C. Currently, we harm our environment by using power sprayers with two-stroke petrol engines. Regular filter cleaning and maintenance are needed. It is about Rs. 70 per hour. Energy costs are rising in tandem with rising demand. Solar-powered spray equipment must be employed to cope with such issues; it is quite beneficial for newcomers.

D. The solar power system in the sprayer makes it easier to light "wireless light traps," which suppress insect pests and minimize the number of insecticide sprays used by 50%.

E. Additionally, this raises the quality of the products by lowering pesticide residues in agricultural, horticultural, and animal products. The mosquitoes are also well controlled by the light traps.

11. DISADVANTAGES

A. Due to the high cost, not every former can afford to provide a solar spray system. If the government can assist formers in obtaining such equipment, it will be beneficial to them.

B. How do I use it? Questions for past students. Before using such a system, formers must receive training in it.

C. Accurately align the solar panel's spray mechanism to prevent panel damage.

D. It can only function correctly in the presence of sunshine; during cloudy weather, it cannot.

12. RESULTS AND DISCUSSION

The developed sprayer is also compliant with the FAO (1994), BIS- 3906 Part I (1982). Matthews and Thornhill suggested that the capacity of the tank should be about 15 liters. Garg (1989) has suggested tank capacities as 10 liters for low volume and 12 to 16 l for medium volume sprayers. Considering total discharge: 1.83 l/min, required pressure: 3 kg/cm2, motor efficiency: 0.80 and pump efficiency: 0.70 required power for motor-pump set calculated was 16.7 W. The net power required for the motor-pump set was computed with a 25% safety factor of 19.5 W. As a 20 Wmotor pump set is commercially available, a 20 W motor was selected for the development.

The developed electronic controller was evaluated for its performance and reliability at different cut-off voltage values for 6 h of load conditions. The controller was also integrated with mobile charging module, which enables the system to be used as mobile charging and enhances its application. It was efficient in preventing the battery from a deep discharging state (i.e. below 10.5 V).

Lead sulfation occurs when power is being taken off from the battery after achieving a battery voltage of 10.5 V. It forms hard crystals of lead sulfate, which cannot be recovered by the standard charging process. The developed charging module was also tested for charging Lead-acid batteries through an SPV panel.

The charging module was effective in delinking the solar power to the battery after complete charging to prevent overcharging. The overcharging of lead-acid battery reactions begins when the majority of lead

sulphate has been converted, typically resulting in the generation of hydrogen and oxygen gases and in turn drastically affecting the battery life. The current for charging is ominously related to irradiation. It was found that even with 65% of irradiation (650 W/m2), the selected battery could be charged fully within 2.5 to 3 hr. The laser diffraction test of both the selected nozzles was suitable for pesticide spraying (Table 1). The value of DV90 for XR11002VP (Y) and XR11002VP (B) nozzle was 258.10 and 350.9 at 2.8 kg/cm2 (40 psi), respectively

TheXR11002VP (Y) nozzle falls under medium droplet size spray application. However, the XR11002VP (B) nozzle may be classified as a coarse application. The relative span of both the nozzles was found minimum (1.28 and 1.32) at 2.8 kg/cm2 (40 psi). It indicated that the distribution of droplet size in the spray spectrum was uniform. It signifies that the selected nozzles require to be operated at 2.8 kg/ cm2 (40 psi) for maximum efficiency of nozzles as well as spray quality.

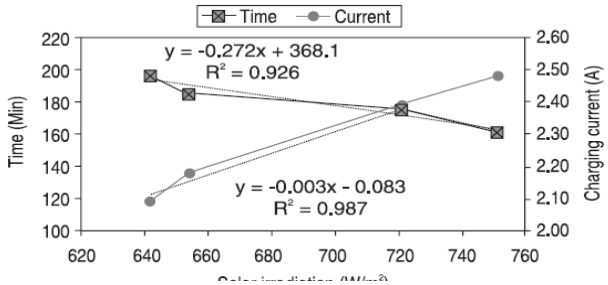

Fig 12Relationship of solar irradiation, charging current, and time for 14 Ah lead-acid battery

Table 1: Nozzle characteristics at a different hydraulic pressure

Pressure kg/cm^2 (psi)	Empirical drop size distribution functions			RSF
	D10	D50	D90	
	XR11002VP (Y)			
1.4 (20)	92.46	173.20	316.00	1.29
2.1 (30)	76.87	130.30	264.80	1.44
2.5 (35)	61.20	136.80	295.00	1.71
2.8 (40)	73.02	145.10	258.10	1.28
3.1 (45)	72.10	141.40	251.40	1.27
	XR11002VP (B)			
1.4 (20)	110.60	328.60	740.60	1.92
2.1 (30)	100.90	237.90	502.20	1.69
2.5 (35)	85.66	184.30	304.60	1.44
2.8 (40)	87.30	165.20	350.90	1.32
3.1 (45)	77.39	161.40	321.50	1.51

The designed 14-liter solar-powered sprayer functions effectively when working at 2.8 kg/cm2 (40 psi) operating pressure to apply pesticides and is outfitted with a system that guards against deep discharge and overcharging of the battery

With the chosen nozzle and operating pressure, it was also discovered that the spray's field of effect was uniform. It would greatly improve spray quality, and chemical potency in the long run, and allow for more effective pest control. This battery can operate the sprayer for six hours and can be fully charged in three hours. In comparison to manual and air-assisted sprayers, solar sprayers covered an area more than twice as large (3000 m2) with the lowest mean heart rate and BPDS, indicating less physiological effort and discomfort to body parts.

13. CONCLUSION

It has been noted that this type of solar sprayer pump for farming is more economical and produces superior spraying outcomes. It is generally accessible for free since it uses solar energy, an unconventional energy source. It may be a better option for the conventional sprayer today when everyone is trying to find innovative ways to meet their energy needs. For farmers who are struggling financially and are now dealing with electricity issues like load shading, we have provided the finest choice. India is a developing nation, thus this product may gain popularity there.

The practical amount of time and current needed to charge a 12V, 14Ah battery to capacity is 14.15 hours. It was also discovered that if we charge the battery for a day, it can be used to spray 200 litters of fertilizer, which equates to about 5-6 acres of land when the battery is fully charged. The suggested system has a little higher installation cost than a traditional sprayer, but it has far lower ongoing costs. The created system was utilized to spray paint, fungicides, insecticides, and fertilizer.

14. FUTURE SCOPE

- By using modeling approaches, the tank's overall weight can be reduced.
- Adopting some new technologies in the electronic domains will boost the battery backup.

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