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Experimental and theoretical study of an agro sprayer operated by using photovoltaic solar panel

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Abstract - A Solar Operated Pesticide Sprayer is a pump running on electricity generated by photovoltaic panels or the thermal energy available from collected sunlight as opposed to grid electricity or diesel run water pumps. The operation of solar powered pumps is more economical mainly due to the lower operation and maintenance costs and has less environmental impact.GY`T6 Solar pumps are useful where grid electricity is unavailable and alternative sources (in particular wind) do not provide sufficient energy. The solar panels make up most (up to 80%) of the systems cost. The size of the PV-system is directly dependent on the size of the pump, the amount of water that is required (m^3/d) and the solar irradiance available. The solar sprayer has many advantages. Besides reducing the cost of spraying, there is a saving on fuel and also, the transportation cost for buying petrol is saved. The solar sprayer maintenance is simple. There is less vibration as compared to the petrol sprayer. The farmer can do the spraying operation by himself without engaging labour, thus increasing spraying efficiency.

***Key Words*: solar panel, DC water pump, spray jet, pesticide storage, atomization.**

1. INTRODUCTION

Agro Solar Sprayer is the energy alternative device. It uses the solar energy instead of fossil fuels for functioning of its system, which decreases the pollution. It is alternative to manually hand operated sprayer which requires lot of effort to spray the pesticides and at the same time, IC engine type is providing good service but its operating cost and maintenance cost is very high. From above major limitations agro solar sprayer which is battery operated type is established.

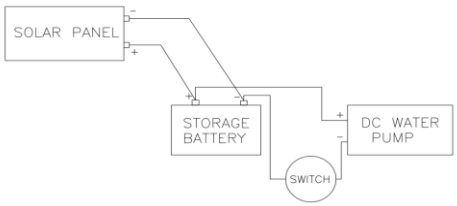
The solar photovoltaic panel traps the solar arrays and this energy is stored in the Lead Acid battery. Battery powers the DC motor coupled pumps impeller and it's used to extract the fluid. Then the fluid flows down due to gravitational force and a pump is attached to the DC motor to boost the pressure in spraying the pesticide. The conventional sprayers cost approximately 9,000-10,000 rupees but the developed agro solar sprayer cost is only 8,000 rupees with more features. The main advantage of the developed project is it does not affect farmer health by any means and also it does not contribute to greenhouse gas emission. This Proposed model proves an efficient and economical way of spraying pesticides and we also found that this method is more reliable.

Solar sprayers are 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 then the energy stored in the battery is utilized to operate motor which functions with pump. A discharge nozzle is connected to pump through pipe and discharge takes place. The applications of this device are in both Agriculture and Horticulture Sectors. This Technology is used for spraying pesticides, Fungicides and Fertilizers.

1.1 FEATURES

- It deals with the variable flow rates at constant discharge of pesticides or fertilizers are possible.
- The weight of agro solar sprayer is very less as compared with engine spray jet which is presently using.
- Solar panel is arranged on top of head of the farmer, so it prevents effect of solar radiation on farmer body.

1.2 OPERATION



1. Line diagram of sprayer

In this device, the solar cells present on the panel are used to convert the received solar radiation directly into electrical energy by means of a PV principle. The electrical energy received from the solar cell is stored in a storage battery unit for application. This stored electrical energy can be converted in to mechanical energy by rotating the motor. For this mechanical operation there is no need of conventional fuel like petrol and oil. The design of solar agro sprayer consist of three main parts namely,

- Solar panel unit

- Storage battery unit
- Rotating motor.

In the agro solar sprayers, the two stroke petrol engine component of the power sprayer has been replaced with a combination of storage battery and rotating motor. The action of the rotating motor could be controlled by a switch attached with it in the assembly. Solar panel arrangement has been provided at the top of the unit to charge the storage battery. The units of solar panel, storage battery and a rotating DC motor were mutually attached with one another. A solar panel of size of 1m^2 area with an output power of 15 watt has been mounted on a rectangular metal frame which is enclosed over the cylindrical chemical tank of capacity of 5L. The solar panel arrangement was made at an angle of 45° to the vertical so that it should not create any trouble to the person who is loading the unit on his back. Moreover it is able to receive maximum solar radiations continuously from the sun during the operation of the unit in the field. The output of the panel is connected in parallel with the 12V storage battery to store the electrical energy from the panel. The 12 V batteries are properly connected with a 12 V DC motor attachment on the frame. The operation of the motor is controlled by a press type switch attached on the assembly.

1.3 COMPONENTS

Agro solar sprayer equipped with the following components:

1. Solar panel
2. Storage device (battery)
3. DC water pump
4. Storage tank
5. Spray jet

1.3.1 SOLAR PANEL

A solar panel (also solar module, photovoltaic module or photovoltaic panel) is a packaged, connected assembly of photovoltaic cells. The solar panel can be used as a component of a larger photovoltaic system to generate and supply electricity in commercial and residential applications. Each panel is rated by its DC output power under standard test conditions [4].

Solar radiation can directly converted into electricity using semiconductor devices, which are known as photovoltaic (PV) cells. When Sunlight falls upon the Solar cell a part of the light is absorbed and it is converted into Electrical Energy by means of Electron Movements. This Solar Panel is connected to 12V lead acid battery for storing the electrical energy.

According to battery output power, following solar panel is selected:

1.2 solar panel

Specifications of Solar Panels:
Panel Size: 30 cm×30cm×0.5cm
Cost of the Panel: 1100 rupees
Weight of the Panel: 1kg.
Power Rating: Voltage: 12 V ,Current: 1.25 A
Power: 12×1.25 = 15 W
Testing of Charging Time:
Instrument used to measure Sun Radiation: Sun Meter
The Sun Radiation are measured in: mW/cm^2
Required voltage for charging the Battery: 12 V.

Power Conversion Efficiency:
The Solar cell Power Conversion Efficiency can be calculated by using the relation,
Where,
P = Incident Solar radiation x Area of the Solar Cell = I x A T
The output power (P) = V x I out

1.3.2 BATTERY

According to motor operating power, following battery is selected
Specification of Battery:
Output power: 108 watts
Output voltage: 12 volts
Output current: 9 amps
Cells: 6 cells

1.3.3 DC WATER PUMP

In principle many different types of pumps can be used to pump water. The most common kind, however, is the centrifugal pump. A centrifugal pump is powered by a device called an impeller. The impeller is a bit like a turbine. It has many curved blades, which channel the water through the pump [6].

1.3. DC water pump

Specification of DC water pump:
Motor Speed: 3000 rpm
Delivery capacity: 3 to 4 feet
Discharge capacity: 4.2lit/min
Operating power required: 86.4 watts
Operating voltage: 12 volts
Operating current: 7.2 amps

1.3.4 SPRAY NOZZLE

Although nozzles are some of the least expensive components of a sprayer, they hold a high value in their ability to influence sprayer performance [7].

Nozzles meter the amount of liquid sprayed per unit area, controlling application rate, as well as variability of spray over the width of the sprayer boom. Nozzles also influence droplet size, affecting both target coverage and spray drift risk.

1.4 Multiple spray jet

2. DESIGN AND MANUFACTURING SIDES

1.5 Agro sprayer

2.1 FRAME DESIGN

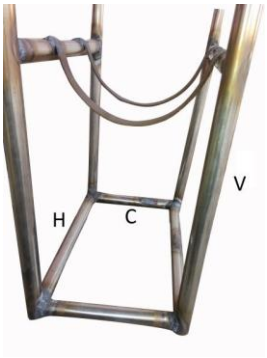
Here we have used various lengths of stainless steel pipes to make the frame in order to support solar panel, battery, DC water pump and storage tank. So it must be rigid and capable bear the loads of all components.

It is made by using fabricating processes of both permanent and temporary. Framing for dc water pump, battery and storage tank is done by permanent fabricating process i.e., gas welding and remaining framing for solar panel is done by temporary fabricating process i.e., bolt and nut arrangement.

2.2 FABRICATING PROCESS

For construction of base frame one horizontal member makes position to the one cross member and welded it and repeat the same for another horizontal and cross members. So that the two right angular structures are made. Finally these two right angles are joined by gas welding and by using filler material.

Four vertical members are welded at the each corner of the base frame weld by taking positing and welding one at a time. Another two horizontal members make position and joined at 10 cm below the upper end of the members parallel to the base frame horizontal members. Two hemi circle beads are welded to horizontal members having a20 cm center distance for supporting fertilizer tank.



1.6 Frame Design

3. TESTS OF THE NOZZLE SPRAYAR

3.1 CALCULATION OF DISCHARGE AT DC WATER PUMP EXIT AND NOZZLE EXIT

Calculations:
Discharge at outlet of dc water pump:
= capacity of a jar (litre)/time to fill the jar (min)
= 2/0.4953
= 4.03 LPM
Discharge at nozzle exit:
= capacity of a jar (litre)/time to fill the jar (min)
= 2/1.11
= 1.80 LPM
Calculations:
Discharge at outlet of dc water pump:
= capacity of a jar (litre)/time to fill the jar (min)
= 2/0.4953
= 4.03 LPM
Discharge at nozzle exit:
= capacity of a jar (litre)/time to fill the jar (min)
= 2/1.11
= 1.80 LPM
Result: Discharge (outlet of water pump)

Theoretical	4.2 LPM
Actual	4.03LPM

1.1discharge at dc water pump exit and nozzle exit

3.2 CALCULATION OF CHARGING TIME OF BATTERY FROM SOLAR PANEL

The time required to charge full battery from solar panel.
Apparatus required:
Stopwatch, Multimeter ,Solar panel ,Battery
Analytical calculation of current and charging time of the battery

The current produced by the solar panel (I) was calculated by knowing the maximum power (P) of the solar panel and the voltage rating (V) of the battery that is given by I=P/V
Therefore,
I=15/12 = 1.25 Ampere
Charging time (T) was computed by taking the ratio rating of battery in ampere hour (Ah) to the total current consumed by the solar panel.
T= (battery rating in ampere hour)/ (total current consumed by the solar panel)

Therefore,
T=9/1.25=7.2hours.
Practical measurement of current and charging time of the battery
The efficiency of the battery
Theoretical power = 12×9 =108 watts
Actual power = 12×7.92 =95.04 watts
Then,
= (95.04/108) ×100
=88.0%
Efficiency of solar panel
Theoretical power = 12×1.25 =15 watts
Actual power = 12×1.02 =12.24 watts
Then,
= (12.24/15) × 100
= 81.6%
Charging time (T) was computed by taking the ratio rating of battery in ampere hour (Ah) to the total current consumed by the solar panel,
= 7.92/1.02
= 7.764 hours
The charging time of the battery using solar panel has been measured by continuously charging battery and it is found those 9-10 hours on the average basis from 10 am to 4 pm (6 hours per a day).
The actual charging time for battery from solar panel is 9 -10 hours.

3. CONCLUSIONS

This technology is most suitable for energy alternative devices for power sprayers. More over the same technique and technology can be extended for all types of power sprayers. As we know 60% -70% of population of our country lives in villages and their main occupation is agriculture. This project main aim is to fulfill the tasks like hand spraying, IC engine spraying, and leg pump spraying etc. using non-conventional energy sources. Thus solar operated spray pump will help the farmers of those remote areas of country where fuel is not available easily. They can perform their regular work as well as saves fuel up to large extent. At the same time they reduce environment pollution. Thus saving revenue of government and most demanded fuel.

cross-section	Capacity of measuring jar (litre)	Time to fill 2lt measure jar(min)
Water pump outlet	2	0.4953
Nozzle exit	2	1.11

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