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DESIGN AND DEVELOPMENT OF SOLAR PV BASED POWER SPRAYER FOR AGRICULTURAL USE

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ABSTRACT

In this study, a solar PV based sprayer has been designed and developed. The developed solar PV sprayer operates both on direct mode by using electricity generated by the component PV panel of the sprayer and also on battery mode using stored electric energy. A DC motor pump is used to generate the required operating pressure to spray the liquid pesticide formulations. A solar PV polycrystalline panel is used to generate required electric energy to operate the DC motor pump in direct mode. On battery mode, the sprayer runs on the stored electric energy in a deep cycle battery (12 V).

INTRODUCTION

India is an agriculture based country. Directly or indirectly 70% people of nation are dependent on agriculture for livelihood. About 20% farmers are commercial farmers and rest 80% are small and marginal farmers. Only commercial farmers can afford expensive spraying technology like tractor mounted sprayer, air craft sprayer, etc.

To meet the energy demand in far-flung areas where grid penetration is neither feasible nor cost effective due to transmission and distribution losses, off-grid electricity generation for low capacity instruments and equipment specifically for agricultural sector is highly important. Such technologies will not only enable the farmers to use latest mechanized machines or tools in agricultural farms but also replaces the machines and tools requiring fuel or conventional electricity for its operation. It will also help in reduce the extra work in field operation.

To meet out the food requirement of the people in India, agriculture production needs to be maintained properly by adopting suitable measures and protection of crop plants from weeds, pests, insects and diseases infestation is one such measure.

Approximately, 35% of the crop production is damaged if pest and diseases are not controlled at right time. Spraying of liquid formulations uniformly and effectively throughout the crop field is mostly followed to control pest and diseases. Using sprayer, liquid pesticide formulations are generally broken down to minute droplets of effective size for uniform distribution over a large surface area.

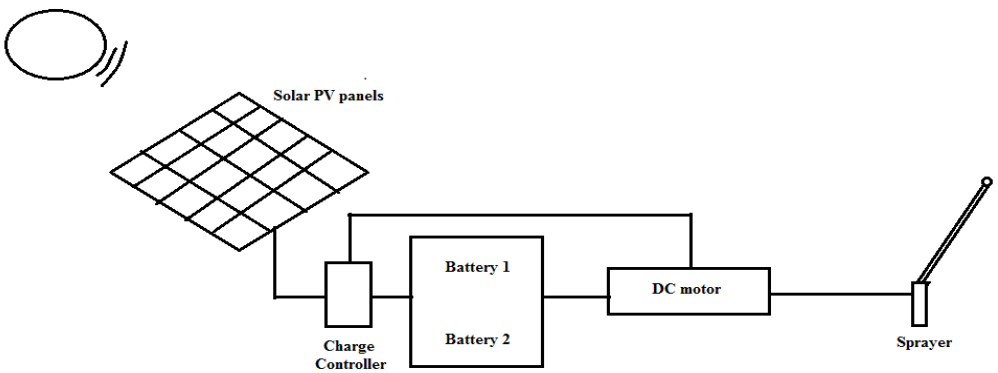
One of the most common forms of pesticide application, especially in conventional agriculture, is the use of mechanical sprayers. Sprayers convert a pesticide formulation, often containing a mixture of water (or another liquid chemical carrier, such as fertilizer) and chemical, into droplets, which can be large rain-type drops or tiny almost-invisible particles. This conversion is accomplished by forcing the spray mixture through a spray nozzle under pressure. The size of droplets can be altered through the use of different nozzle sizes, or by altering the pressure under which it is forced, or a combination of both.

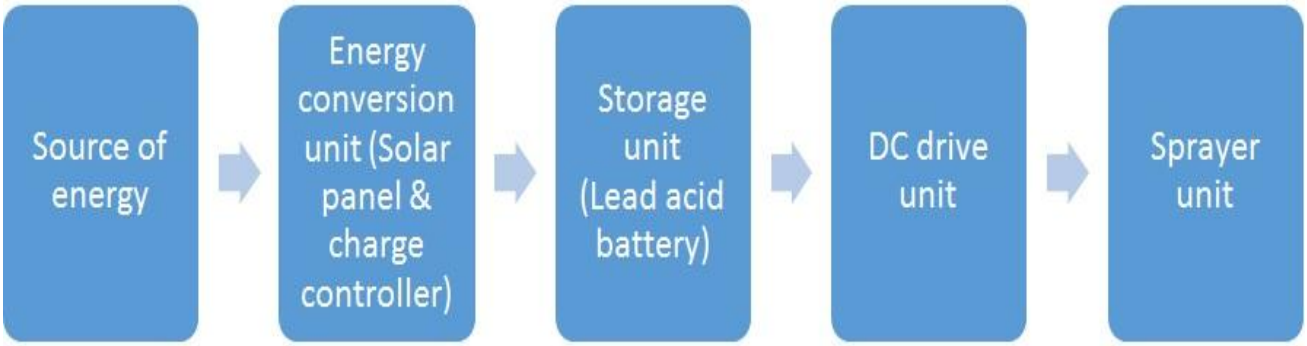
To explore the possibility of maximum use of freely available solar energy in India, national solar mission was launched in November 2009 with a target of 4000 MW grid and 1000 MW off-grid electricity generation from solar energy by the end of phase II (2013-2017), whereas these targets are 20,000 MW and 2000 MW, respectively by 2022.

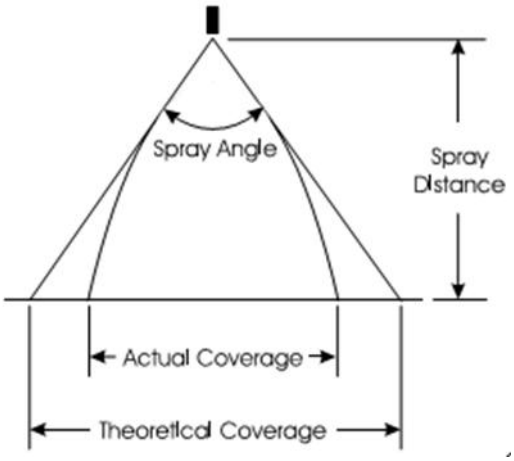
The objective of this research work is to design and development of solar PV based sprayer, which can reduce the cost & manpower and to get the work done timely & effectively. Solar power will be considered as an energy source. To reduce the manpower, a portable type PV operated sprayer is to be designed for spraying of the different liquid formations in agricultural farm. To reduce the cost, lightweight material components are to be fabricated and ensemble.

CONCEPT OF SOLAR POWERED PV SPRAYER

The proposed system consists of following units: (i) energy conversion unit for generating electricity from solar irradiation using solar PV panel, (ii) energy storage unit in the form of battery, (iii) DC motor with pumping system and (iv) sprayer unit. All these components are shown in Figure





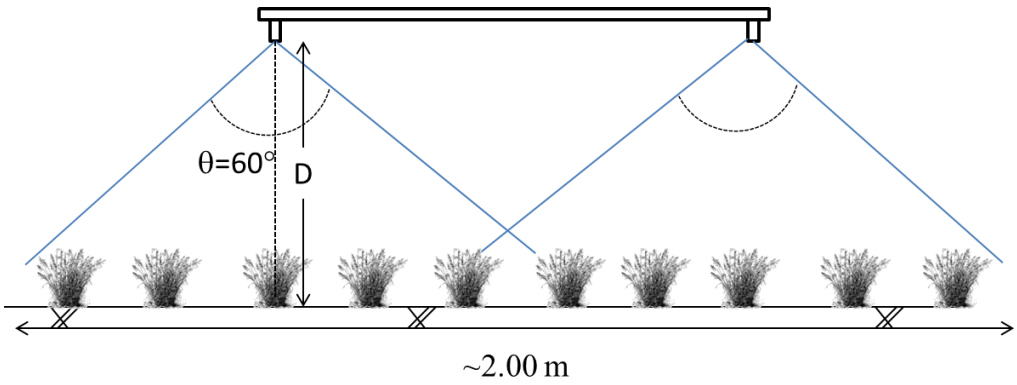


Theoretical coverage of spray nozzle can be calculated using the following equation:

Theoretical coverage = 2× D tan (θ/2)

Where D is the spray distance,θ is spray angle.

For example, if the spray angle is 60° and the spray distance is maintained at 1 m height, then the theoretical coverage will be 1.154 m (tan 30° = 0.557). If we consider the actual coverage as the 90% of the theoretical coverage, then the ground coverage by a single nozzle will be about 1 m. therefore, if we adjust two nozzles 1 m apart at the end of a single rod frame as shown in Figure, we can obtain ground coverage of 2 m.



If we take θ = 65° and D ~ 1.3 m, then theoretical coverage = 1.65 m by single sprayer. So for two sprayer it will be 3.31m.If we consider actual coverage area to be 90 % of

theoretical, then actual coverage area will be around 2.98 by two sprayers which is very effective.

Theoretical spray coverage at various distances from nozzle orifice

Spray angle	10 cm	20 cm	25 cm	30 cm	40 cm	50 cm	60 cm	70 cm	80 cm	100 cm
15°	2.6	5.3	6.6	7.9	10.5	13.2	15.8	18.4	21.1	26.3
25°	4.4	8.9	11.1	13.3	17.7	22.2	26.6	31	35.5	44.3
30°	5.4	10.8	13.4	16.1	21.4	26.8	32.2	37.5	42.9	53.6
35°	6.3	12.6	15.8	18.9	25.2	31.5	37.5	44.1	50.5	63.1
40°	7.3	14.6	18.2	21.8	29.1	36.4	43.7	51	58.2	72.8
45°	8.3	16.6	20.7	24.9	33.1	41.4	49.7	58	66.3	82.8
50°	9.3	18.7	23.3	28	37.3	46.6	56	65.3	74.6	93.3
60°	11.6	23.1	28.9	34.6	46.2	57.7	69.3	80.8	92.4	115
65°	12.7	25.5	31.9	38.2	51	63.7	76.5	89.2	102	127
70°	14	28	35	42	56	70	84	98	112	140
75°	15.4	30.7	38.4	46	61.4	76.7	92.1	107	123	153
80°	16.8	33.6	42	50.4	67.1	83.9	101	118	134	168
90°	20	40	50	60	80	100	120	140	160	200
95°	21.8	43.7	54.6	65.5	87.3	109	131	153	175	218
100°	23.8	47.7	59.6	71.5	95.3	119	143	167	191	238

LITERATURE REVIEW

Joshua R. [1] reported that power sprayer with two stroke petrol engine has a high operating cost as well as has many difficulties e.g. operating cost is much higher, Rs.70-75 per hour which is not affordable by the poor farmers, need of regular maintenance etc. To overcome such difficulties, they suggested a solar operated sprayer. A solar sprayer has zero operating and maintenance cost as it can run on solar energy. The difference seems significant as one can save Rs 280 per day. In the suggested model, a single motor replaces the two-stroke petrol engine.

VV Rao [2] studied the multiple power supplied fertilizer sprayer. The focus of their study was on the design and implementation of fertilizer sprayer. A DC motor was used in place of modified model of two stroke petrol engine. They reported that it was less in noise, had longer life and require low maintenance. In the proposed system, the sprayer is made up of with energy conversion unit, storage unit, display and protection unit, DC transmit unit and spray unit. In energy conversion unit, a wave bridge rectifier was used to convert AC to DC in absence of solar energy.

Zoeb khan [3] suggested in his study to use non-conventional energy for remote areas of the country. In agriculture sector, there is a big scope for use of non-conventional energy. A solar based sprayer can be beneficial to the farmer for timely and efficient use of chemicals in the field. In 2014, Zoeb khan designed a spray jet for cultivation users by using solar panels. The researcher found that replacing the diesel engine with DC motor would be a better option.

The study was conducted by **Ashish P Patil [4]** on performance evaluation of solar operated knapsack sprayer. The weight of solar panels as well as overall designed sprayer puts on shoulders which ultimately provides effortless operation. It also has been observed that solar panel provides shadow on the head of user which protects him from high solar radiations. This sprayer can run 2.5 hours more after 5 hours of operation in full solar intensity so system can also be used at night.

Pandurang B. [5] developed a solar operated pesticide sprayer for agricultural use. In their study, they have suggested that the internal combustion engine is replaced by solar powered pump sprayer which is more economical mainly due to the lower operational & maintenance cost. It has less environmental impact than internal combustion engine and eco-friendly nature.

Sarvesh kulkarni [6] reviewed a solar powered pesticide sprayer. The main focus was implemented on solar powered sprayer working on different conditions. It is observed that the system developed for solar powered pesticide sprayer is more cost effective and it gives effective results in spraying operations. Considering the availability of the solar energy at free of cost, this system can become more popular in rural areas.

In the proposed study by **Ritesh chavan [7]** they tried to solve the problem of preventing overcharging and protecting overvoltage. It was ensured by adoption of pulse width modulation technique (PWM). Its main advantage is that power loss in switching device is very low. The output from charge controller is given to the battery by 3 pin socket through an electric network. Reverse engineering principles were adopted to design the system. According to the study, 0.6-0.9 m height of delivery pipe held horizontally gives good results. A java program was developed to solve equations of nozzle dimensions and head developed by pump. The solar panels were selected considering the ability to charge the battery and weight criteria.

Pranil V Sawalakhe [8] stated that the solar powered seed sowing machine basically works on vertical discontinuous work principle. The vertical movement can be followed by an individual body in agriculture field. Its discontinuous action in relation to the horizontal line of work. The use of the machine is to improve agricultural soil carbon sequestration. Work on zero tillage system, seed can be placed at proper depth and mix cropping can be easily done. In the present study, with the solar powered seed sowing machine authors claim to save energy, sowing time and reduction of labor cost to help small scale farmers. According to them, this machine maintains row spacing and control seed rate & seed depth.

Siddharth kshirsagar [9] made some efforts to design and develop a vehicle because till date only backpack sprayers are in use traditionally. The author's criteria was to select and design a gear drive system for the wheel shaft to pump driver linkage mechanism. In the system, a mild steel fabricated structure is the base frame of the chassis, which holds the entire assembly. Drive assembly works on the system that when the system moves forward, the rear shafts rotate the wheel. The material used for manufacturing are alloy steel for shaft and nylon 66 for gear.

Paul E Sumner [10] stated that weed control plays an important role in increasing the productivity of crop. Manual weeding is very costly and time consuming and therefore spray of weedicide is a cost effective method to control the weed population and realize more crop yield. A study by Paul E. Sumner showed Air-assisted electrostatic and hydraulic sprayers developed in recent years to improve pesticide deposition within the plant canopy and on the undersides of cotton leaves were evaluated to determine their effectiveness compared with conventional sprayers. The study determined and compared within-canopy deposition of spray from conventional hydraulic nozzle, air-assisted, and electrostatic sprayers in cotton plants. Water sensitive paper, residue washed from leaves, and fluorescent dye collected on strings were used to determine the effect of sprayer method on spray deposition within the canopy and on cotton leaf surface.

CONCLUSION

- The main emphasis of the project was to design and development of solar based power sprayer for agricultural use including the selection of solar PV panels, DC motor and sprayer nozzle.
- Considering the limitations of funds and fulfillment of the power requirement, two 100 W (50W each) solar PV panels were used.
- Due to bad weather conditions when solar irradiations are not available, battery option was provided.
- The fully charged battery can be used to spray 200 liter and 400 liter of pesticide by using single and double nozzles respectively.
- The overall design of the sprayer provides spraying operation facilities at night also.
- Used hollow cone nozzle sprayer for better efficiency.
- If spray angle is more than 60^{o} and spraying height is around 1.3 m better operation is performed effectively.

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