Design and Development of Solar Assisted Automated Pesticides Sprayer

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***Abstract*— protecting crops against weeds, insect pest, and germ is becoming a biggest challenge for the farmers. To overcome this issue, agricultural chemicals (pesticides) are applied to crops. For this purpose a pesticide sprayer is employed. Although many sprayers are commercially available, none is optimised in terms of pesticide consumption, spray characteristics and cost of sprayer. 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 analyzed 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 green house gas emissions. It has also been proven itself to be an efficient, reliable and economical one to spray pesticides for agriculture applications.**

***Keywords*— Solar Panel, Pesticides Sprayer, Dynamo, DC Pump, Photovoltaic effect**

I. INTRODUCTION

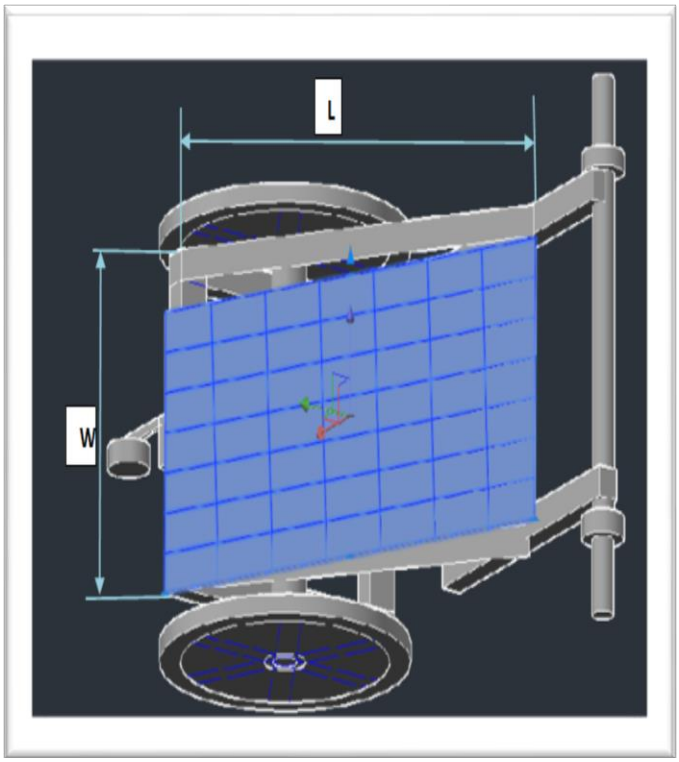
The basic principle of pesticide sprayer is to appropriately target the required place which enhances the effective usage of agricultural chemicals. To favor so certain factors which matters a lot are size of the droplet, type of sprayer nozzle, target timing, drift, proper use of sprayers, evaporation of droplet, weather condition, volatilization, distance and height of spraying. This will result in proper uniformity of droplet distribution. Pesticide sprayers are of different types such as manually carried type and mechanically power driven type [1]. In 1980, boom sprayer was developed in France and USA however it was first practically implemented in Australia in the early year of 1900 [2]. Rutherford et.al [3] has highlighted certain advantages of the boom and hydraulic nozzle system of sprayer. In their articles they also discussed about the effectiveness, versatility, efficiency, quickness response as far as usage of farmers were concerned. Also some researchers also suggested about less risky factor of operator usage and environment concern of sprayers. Many researchers suggested advanced technologies and approaches based on factors affecting spraying quality and uniformity of droplet size & distribution, in order to optimize chemical consumption and prevent soil contamination [4-5]. It has been estimated that for common users, advanced plants and weeds recognition system is expensive [5-7].By segregating the interrelated dynamic process into a series of processes, the loss of agricultural chemicals can be minimized [8]. It has been reported in literatures [6-9] that agricultural chemicals wastage is due to several reasons such as inadequate use of sprayer, drift and evaporation of droplet, dilution, high temperature, washout, volatilization, hydroxylation, photochemical degradation, absorption and drainage of soil, bacterial degradation, dissolution, etc. High intense spray pattern results in low drift and non uniform droplet distribution. However, with low intense spray pattern, more drift and uniform droplet distribution can be obtained. Also, uniform droplet distribution and small droplet size is possible with increasing vertical distance or height between nozzle tip and target. But in this case drift will be more which can cause physical damage to the crops. Also, it is a challenge to optimize these parameters simultaneously to obtain uniform droplet distribution and low drift, with low intense spray for getting minimum wastage of chemical and maximum performance of the nozzle [10-13]. In addition, it is reported that performance of boom type sprayer is affected by wind direction when the sprayer is parallel to wind direction [10-12]. Fulton et.al [14] suggested that the volume of fluid spray of the protective fungicide could be reduced often, with equal and better efficiency to control the plants disease, provided the dose per unit area on the basis of active ingredient is not lowered. By selecting a proper droplet size of sprayer, the droplet density has been calculated from a graph plotted by Johnston [15]. The nozzles employed in sprayer were classified based on droplet size, velocity, pressure, and energy [16].The performance of spray nozzles also depends upon the height of crop, shape and size of leaves and skill of the operator [17]. Maximum efficiency for a spraying system with optimized air flow rate, agricultural chemical liquid and spray drift were reported in [18]. Based on the diameter of droplet, the spray droplet was classified as aerosol, mist, fine spray, medium spray and coarse spray with volume median diameter of less than 50 µm, 51-100 µm, 101-200 µm, 201-400 µm and greater than 400 µm respectively [18]. Wilson et.al [19] performed experiments extensively to analyze the spreading and effect of disease with variation of the droplet size of sprayer. It has been suggested that the pesticide droplets whose volume median

diameter size value ranges from 100 to 400 µm gave good impact for controlling diseases whereas 500 µm droplet sizes was completely in effective [19]. The effective range of volume median diameter for different pesticides applications to control diseases such as fungicide, insecticide and herbicides had been proposed in [20]. Some researchers also recommended the probable droplet size for particular application of agricultural chemicals by using heavy vehicle mounted sprayers. It has been reported that the droplet size ranging between 150-300 µm was found to be effective for herbicide applications especially for tractor mounted sprayer [21]. Similarly for insecticide and pesticide applications the proposed suitable size of the droplet was around 15-20 droplets per cm^2 [22]. Karthik et.al.[23] proposed a solar based manual agro sprayer for rural small scale application. These presently used models of small scale agro sprayers were basically manually operated and their pumps were run using power generated from fossil fuels. The major complications of the system were found to be too heavy to carry manually and expensive fuel.

In the present work, a novel design and fabrication of solar powered pesticide sprayer with capacity of 5 liter has been proposed. This can be suitable for small scale farming applications of maximum 2 acres of planted field. The proposed designs are preferably applicable to boundary plant such as chilies, grass, cabbages or cully flower, etc. It can also be used for shrub type of plants whose plant-to-plant space ranges between 0.6 to 1 m. In the present work, the issues prevailing in the commercially existing models are addressed with help of solar photovoltaic cells that are used in place of fuel tank which reduces the gross weight of sprayer. The provision of wheel arrangement in the new design made the sprayer movable one.

II. METHODOLOGY

The design concept of the proposed model has been started after an extensive literature survey with a sketch before final design of the model is made. The major challenge here was to choose exact location of fixing the nozzle, dynamo, solar panel and battery which are the essential components of the entire system. Line diagram has been done with proper care followed by design concept. Soon after the design concept is finalized the same has been solid modeled by using AUTOCAD software package. In view of Indian agricultural land and crop condition the length (L), width (W) and height (H) of the sprayer is determined. The length between rear and front wheel is 55 cm and the distance between two front wheels is 55 cm. Moreover the clearance between wheel shaft and frame is 50 mm each. Similarly the height from frame to handle is 85 cm. During this period of design it has been verified properly about numerous aspects, to comply like ergonomic and safety. The practical feasibility, function ability of the fabricated model in reality was also checked in every steps of design



(a)

(b)

Fig. 1. Model design using Auto-CAD (a) top view, (b) side view.

III. FABRICATION PROCESSES INVOLVED

Before going for fabrication process a theoretical layout procedure for fabrication has been prepared depending upon the availability and suitability of materials with dimensions. The fabrication methods also were being finalized after surveying different literatures related to the work. The different processes involved during fabrication work have been illustrated in a layout as shown in Fig.2.

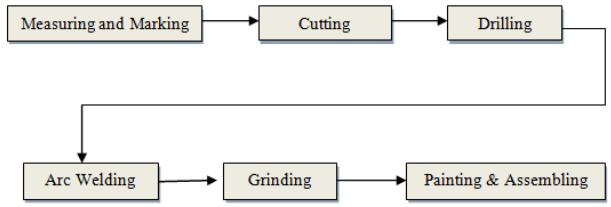


Fig 2. Layout diagram of different processes involved in fabrication

Fig. 3. Photos captured during fabrication of sprayer frame

A. *Components of Fabricated Model*

The different components along with their technical details have been mentioned in table 1.

TABLE I. SPECIFICATIONS OF MODEL

Sl. No	Components Details			
	Parts	***Quantity***	***Features***	***Technical Details***
01	Wheel	03 Nos.	Nylon Fiber	φ 48 cm
02	Handle	01 No.	Mild steel with cover	60 cm length
03	Frame	-	Mild Steel	120 cm
04	Bicycle Dynamo	03 Nos.	Constant Current output type	6V, 3W Output (each)
05	Submersible Pump	01 No.	PVC with outer body, 9watt motor,	Can lift water up to 1.2 meter height, pumping capacity 50 liters per hour
06	Battery	02 Nos.	12 volt lead acid battery,	2.5 AH capacity
07	Charge Controller Circuit	01 No	Light Weight(40.0 grams), zero drop, shunt type	Voltage regulation: 5mV (no load to full load) Battery discharge: 1m A (Chinese controls discharge at typically 3mA)
08	Pesticide Tank	01 No	Commercially available PVC Type	6 Liter capacity
09	Hose Pipe	02 Nos.	Rubber and flexible, light weight	Pressure -30 MPa Size-2 cm inner diameter
10	Valve	01 No	Easy to regulate flow rate	½ inch diameter 5 psi pressure
11	Pressure Switch	01 No	Electronically controlled Light weight, small size with stainless steel impeller shaft	External threads: 1/2 inch
12	Nozzle	03 Nos.	Full Cone Spray Pattern, For fine mist to jet stream	0.3 mm nozzle tip diameter with nozzle include spray angle 45^0
13	Solar Panel	02 Nos.	Polycrystalline solar panel with strong aluminum frame	12 volt, 10 watt capacity

IV. ASSEMBLING PROCESS

The assembling process and painting was done after fabrication is completed. During assembling some challenges were experienced such as proper alignment of wheels, etc. But with proper care and trial error method it has been completed well. The detailed components of the working model (automated pesticide sprayer) after assembling are depicted in Fig. 4.

Fig. 4. Photograph of fabricated sprayer

V. EXPERIMENTATION

The solar radiation is allowed to fall directly on the solar panels of the sprayer. The solar radiations are directly converted to electric power through solar panel based on photovoltaic effect. The same power is supplied to two Lead-Acid batteries connected in series for charging. The stored energy in battery is utilized for pumping system. Power is utilized to spray the pesticides in day and night whenever is required. One charge controller is incorporated in the set up to prevent the battery from overcharging in order to increase the life of battery. Similarly some additional DC power is generated from two dynamos attached to rear wheels and this power is also used to charge the battery. Although the amount

of power generation by DC-dynamo is less compared to PV panel it can be employed to supplement the power supply. The DC power output coming from the battery is supplied to the submersible pump to operate sprayer. The submersible pump is dipped inside the pesticide tank of capacity 5 liter. The pump is operated with designed pressure and pesticide is sprayed to the crop up to a adjustable height through three nozzles. These three numbers of nozzles are connected with single hose pipe through which pesticide is pumped as shown in Fig. 5. A flexible support is provided so as to adjust the nozzle height to suit to the plants height. The maximum height it can hit target effectively is two feet.

VI. SPECIAL FEATURES OF PROPOSED MODEL

- The cost of operation and maintenance of solar agro sprayer is negligible.
- Suitable for remote area agricultural lands for pesticides spraying where conventional energy is not available.
- Environmental friendly equipment
- Low cost , economic, efficient compared to other equipment
- Simple to handle, install, durable

VII. CONCLUSION

In this proposed model, solar powered automated pesticides sprayer, the farmers health factors, spray characteristics, weight and cost of sprayer have been given more priority while designing. The weight of sprayer is reduced by incorporating the solar panels in place of fuel tank of the existing sprayers. Also the proposed design is suitable for remote area or region of agricultural land without any conventional energy source and moreover it does not emit any green house gases to the environment. Also the cost of the present sprayer design is minimized by taking the concern of economic conditions of farmers and hence it is quite affordable to village farmers with small and medium level agricultural cultivations. The major merit of the present design is that the farmers do not require any special skill to operate the sprayer. During performance testing of the sprayer, it is physically confirmed that the spray effectiveness is appreciable and is influenced by the factors namely the uniformity of droplet distribution, wind speed, ambient temperature, relative humidity, spray pressure type of spray along with spray height and spray pressure.

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