Environment and Ecology 40 (3) : 1171—1178, July—September 2022
ISSN 0970-0420

Evaluation of Solar Panel for JNKVV Push Type Solar and Battery Operated Sprayer

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Received 23 November 2021, Accepted 12 March 2022, Published on 15 July 2022

ABSTRACT

JNKVV push type solar and battery operated sprayer is an agricultural sprayer, which utilizes solar energy with the help of solar panel as source of power for chemical spraying operation. It consists of a solar panel of 12 V-50 WP capacity, a 12V DC battery, charged by Photovoltaic (PV) panels which are used to produce electricity directly from solar energy, a DC motor, worked by the DC battery through charge controller, a pump, to spray the chemical and a tank to seize the spraying liquid. The whole JNKVV push type solar and battery operated sprayer is transportable and managed by one person. The efficiency, operating time and superior output of JNKVV push type solar and battery operated sprayer mainly depends on the capacity of solar panel. The performance evaluation of the solar panel of sprayer was carried out for practically and theoretically spraying in pigeon pea crop in farmer's fields. Designed push type sprayer does not utilize any additional external resource of energy and that it is functioned by the operator self, it decreases drudgery, is fairly economical and environmental friendly as it uses solar energy which can be effortlessly affordable by small farmers. It was studied that the time required for charging of battery of 10.3 V starting at 11:00 am was found to be 1.50 h to achieve full voltage of 13.3 V. It was revealed that without solar photovoltaic panel, sprayer was operated only 1 h 30 min, which indicates the selected solar panel, is sufficient for continuous operation in selected location by reason of local climate factors. Solar panel efficiency also depends on local climate factors such as solar intensity, cloud covers, temperature.

Keywords JNKVV push type solar and battery operated sprayer, Solar panel chemical spraying.

INTRODUCTION

Renewable energy sources are the most preferable resources for generation of electricity because of environmentally friendly. All the renewable energy sources, solar energy are the most available resource and it is pollution free. A solar cell is a device that converts light energy directly into electrical energy via photovoltaic effects or photochemical reactions. In 1839, the French physicist Becquerel discovered the PV effect for the first time (Zhou *et al.* 2018). Usually the energy needed for chemical spraying is

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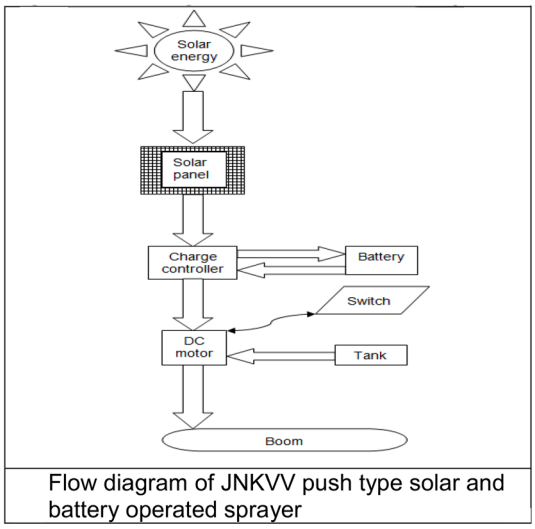

Fig. 1. Flow diagram of JNKVV push type solar and battery operated sprayer.

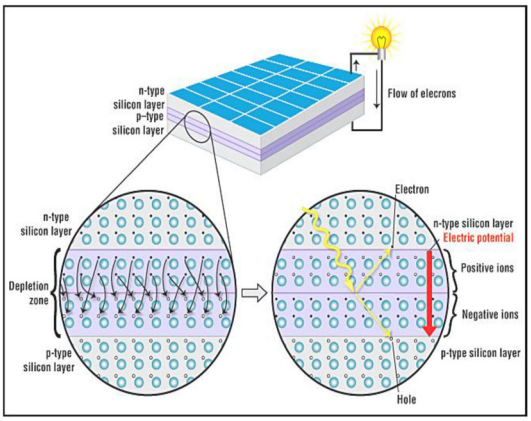

Fig. 2. The movement of hole and electrons resulting flow of electricity across the cell represented.

from either alone or grouping of manual source and mechanical energy. Sometimes the batteries are used for the sprayer for discharging the spraying liquid. But these batteries require electricity for charging them. However, due to increasing in the cost of fuels and their inadequate accessibility, there is currently superior knowledge of the need for development of renewable energy implements (Basavaraj Rajaiah *et al.* 2020). Hence, there is a larger scope for use of solar power for generation of electrical energy using solar cells and further to use the same for spraying operation. "Energy-demand" is one the major thread for our country. Finding solutions, to meet the "Energy-demand" is the great challenge to our Country. Now-a-days the Concept and Technology employing this Non-conventional energy becomes very popular for all kinds of development activities. One of the major area, which finds number applications are in Agriculture Sectors. Precision guidance and precision sprayer control have substantial promise to reduce input application overlap, thus saving chemicals, fuel and time during the application process (Praveen and Srivastava 2020). Most of Indian farmers are completely dependent on agriculture, which comprises small, marginal, medium farmers. Therefore the small and medium scale farmers cannot afford mechanical power type of sprayers, because of high price (Shrivastava and Praveen 2021). Manually operated sprayers are operated by the person but drawback is it causes fatigue to operating person and hence cannot be used for longer time and fuel operated sprayers are operated using fossil fuels but drawback is its cost of operation is high due to fuel used and also emits pollutant gases which leads to environmental issues and Electrical sprayers are operated on electricity for charging the battery which drives the pump but drawback is it can't be used in some of rural areas due to insufficient supply of electricity (Chandrashekar *et al.* 2018). To overcome these drawbacks we could think on non-conventional energy sources like wind energy, solar energy, tidal energy, considering above mentioned problems we have developed a solar operated push type sprayer and also done suitable solar panel for developed sprayer based on requirement.

Fig. 3. Solar photovoltaic panel.

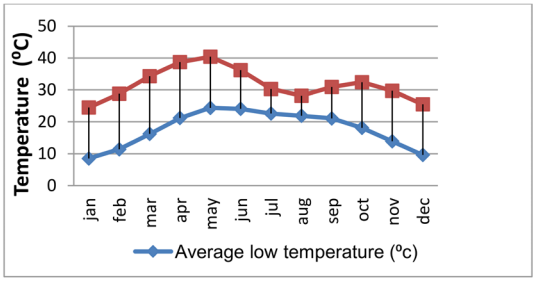

Fig. 4. High and low temp of every month through out year.

MATERIALS AND METHODS

Solar photovoltaic and battery operated sprayer

Solar and battery operated sprayer was designed to spray the chemicals in the fields. The designed solar sprayer mainly consists of a solar photovoltaic panel, charge controller, battery, dc motor, pressure control valve, filter, switch, and tank. Handle and all components are fixed to trolley with nut and bolt adjustment for fixing different heights. The spray tank was connected to the boom with the aid of distributing flexible rubber hose passing through the DC motor. The vertical boom supporter was bolted at the front of the main trolley. The boom supporter was designed in the way that the boom height could be adjusted as per the crop height between 400 mm to 2000 mm above the ground. The hose pipe of boom also adjusted on the horizontal bar of boom supporter and four nozzles are adjusted to the hose pipe. The distance between each nozzle was 60 cm and this width is adjusted by aluminum clamps depending upon the crop width from 600 to 900 mm. The chemical in the spray tank is pumped to the flexible hose by the dc motor when motor is started. Sun rays transfers into photovoltaic plate during the day time. Battery is charged by charge controller through solar panel and the electricity is stored in this battery. In order to supply reduced voltage from battery to pump a charge controller is used. The overall weight of push type solar photo-voltaic and battery operated sprayer cum weeder was 35 kg. Fig. 1 clearly designated the details of Auto CAD drawing with labeled parts of developed push type solar photo-voltaic and battery operated sprayer.

Solar photovoltaic panel

Solar power can be generated by two techniques. That is solar PV i.e., through SPV panels and another one is solar thermal i.e., through concentrated solar electrical energy. Multi crystalline cell type was selected for this sprayer system.

Working principle

Solar rays are made out of small energy pockets named photons and that every individual photovoltaic cell is planed with a negative and positive coating thus being able to generate an electric power field (similar to the one in battery). As photons are attracted in the photovoltaic cell their energy sources electrons to get free, and they shift to the bottom of the photovoltaic cell, and exit through the connecting wire which creates flow of electrons thus produce electrical power. The larger quantity of the available solar rays the larger the flow of electrons and the more electrical energy gets created in the procedure. It is

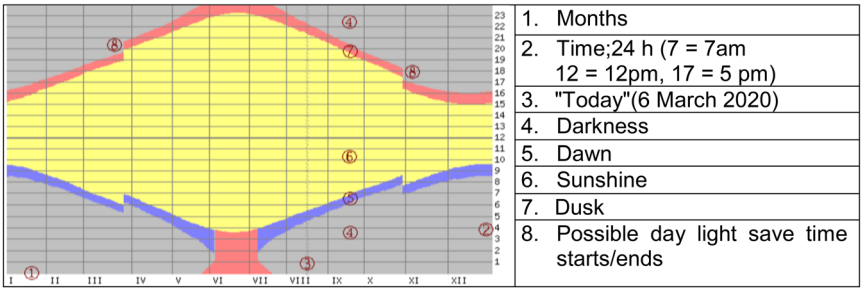

Fig. 5. Sun shine hours of Jabalpur.

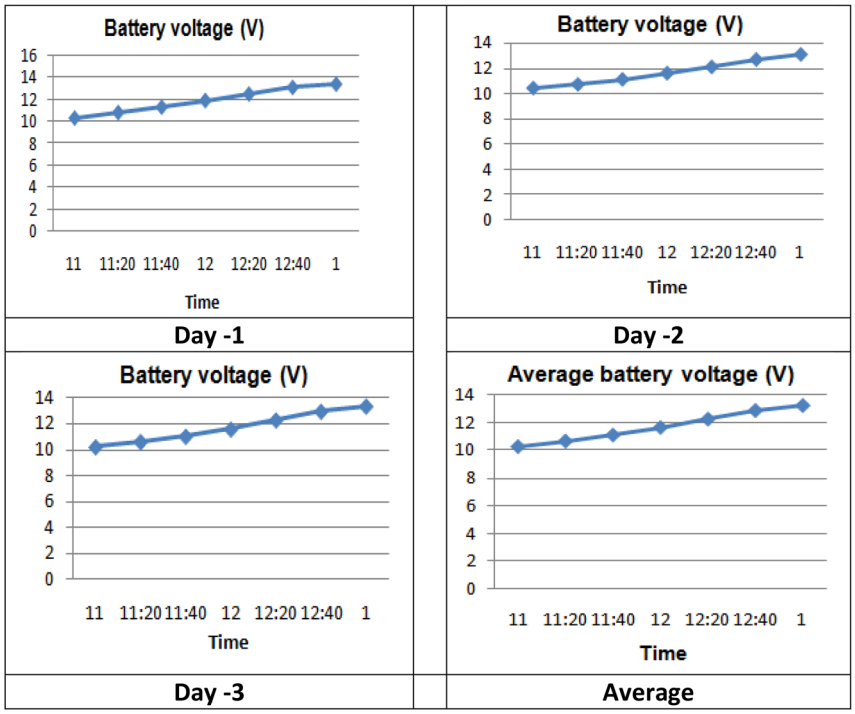

Fig. 6. Time required for battery charging with a solar panel.

a form of solar cell (in that its electrical naturalistic e.g., current, voltage, or resistance differ when radiations are split upon it) which, when exposed to solar rays, can generate and support an electricity without being attached to any outside voltage supply, but do need an external load for energy consumption. Pure silicon is a poor conductor of electrical energy. The group of holes and electrons are characterized in below Fig. 2. Depletion area maintains to grow till the electric field becomes large enough to prevent the flow of energy carriers from one side to another side. Now, if the diode is exposed to sun radiation, it frees the electrons in n-region and these electrons, prevented by the electric field, flow through the load to p-region (6). These electrons constitute electric power. The movement of holes and electrons can be characterized as follows :

Solar radiation can directly converted into electricity using semiconductor devices, which are known as photovoltaic cells. When sunrays incident upon the photovoltaic cell a part of the beams is absorbed and it is transferred into electricity by means of electron movements. This electrical energy can then be utilized to supply renewable energy to battery. The Photovoltaic or solar panel of 12 V, 50 W capacity configured to trap and convert the sun's energy into the useful

Table 1. Monthly average solar intensity and average solar insolation of Jabalpur.

Sl. No.	Month	Average solar insolation (kWh/m²/ day)	Average solar intensity (W/m²)
1	January	4.28	409.5
2	February	5.10	459.0
3	March	6.11	531.7
4	April	6.87	559.4
5	May	6.91	529
6	June	5.47	411.2
7	July	4.22	327.1
8	August	3.78	302.4
9	September	4.52	366.8
10	October	5.26	456.5
11	November	4.76	453.3
12	December	4.20	391.

Fig. 7. Testing discharging of battery with multimeter.

power was used to perform the work of spraying. Solar PV Panel was used for operating the sprayer and for charging a battery. Solar power is arguably the cleanest, most reliable form of renewable energy available, and it can be used in several forms to help power appliances. By lowering utility bills, these panels not only pay for themselves over time, they help reduce air pollution caused by utility companies.

This Solar panel is connected to 12V lead acid battery through charge controller for storing the electrical energy. In market, 50 Wp solar panel is available, hence 50 Wp solar panel is considered for this project. According to battery output power, following photovoltaic panel was selected (Fig. 3).

Insolation

The monthly average quantity of the total solar radiation falls on a horizontal surface at the surface of the earth for a given month, averaged for that month over the 22-year period. Each monthly averaged value is estimated as the numerical average of 3 hourly values for the given month (NASA Langley Research Center Atmospheric Science Data Center).

Solar intensity

Solar intensity is that the power per unit area (W/m^2), observed from the sun within the form of electromagnetic wave as reported within the wavelength range of the measuring instrument. Solar irradiance is usually integrated over a given period of time so as to report the energy emitted into the enclosing environment (J/m^2), during that point period. This integrated solar irradiance is named solar irradiation, solar exposure, solar insolation, or insolation. The efficiency of a solar photovoltaic panel is affected by irradiation and panel temperature. The solar radiation contains radiant energy as well as thermal energy, but PV power generation is only effected by the solar energy. The past decades have seen the rise in solar energy demand for reliable and clean sources electricity. The generation of solar energy is based on the sun rays of intensity on the PV panel and the wavelength of radiations.

Short circuit current (Isc) of solar cell

The short circuit current is the highest current that a photovoltaic cell can supplied without damaging its own constriction. It is measured by short circuiting the terminals of the cell at most optimized condition of the cell for producing maximum output.

Open circuit voltage (Voc) of solar cell

It is measured by measuring voltage across the terminals of the photovoltaic cell when no load is attached to the photovoltaic cell. This voltage depends upon the techniques of constructing and temperature but not fairly on the intensity of sunshine and area of exposed surface.

Specifications of solar panel

Cell type = poly crystalline
Open circuit voltage V_{oc} = 21.00 V

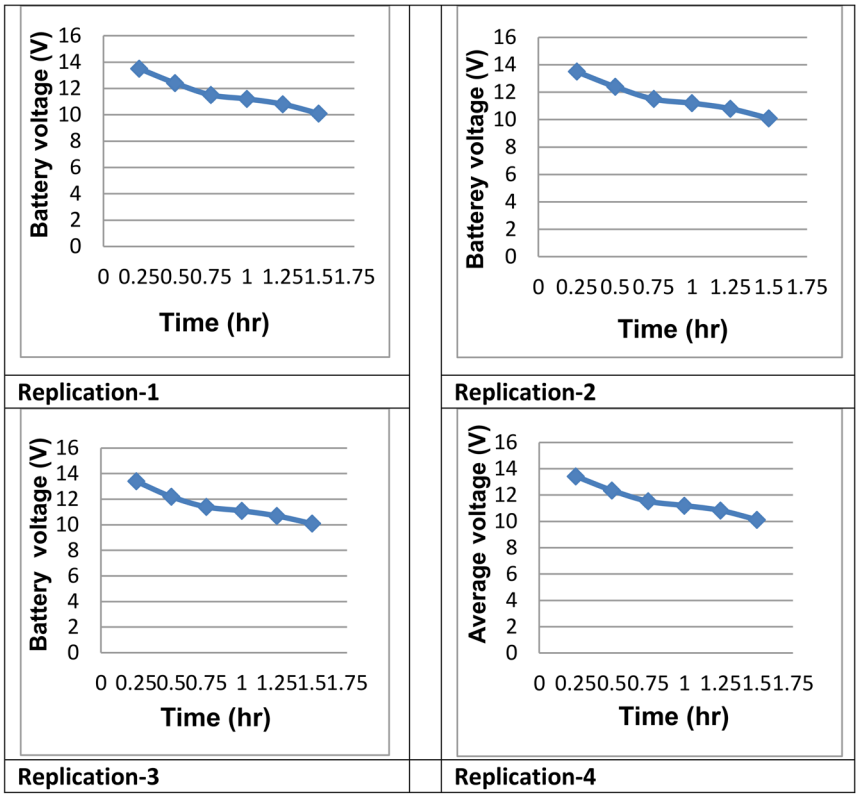

Fig. 8. Testing of battery discharging of sprayer unit while working condition.

Short circuit current I_{sc} = 2.82 A
Rated voltage V_{mx} = 17.5 V
Rated current I_{mp} = 2.63 A
Rated power P_{mx} = 50Wp
Specifications of Solar Panels :
Panel Size: 54.5 ×66.5 ×3.4 cm^3
Weight of the Panel : 4.5 kg
Module efficiency = 12.6%
Module temperature = 25°C

RESULTS AND DISCUSSION

This chapter describes results obtained from the laboratory and field experiment for individual solar sprayer unit. The experimental prototype was fabricated in the Farm Machinery Work Shop, CAE, JNKVV, Jabalpur. The performance of solar and battery operated sprayer trails were observed in the actual field condition of agriculture research farm of JNKVV, Jabalpur.

Solar and battery operated sprayer unit working with solar energy, so it needs adequate climate conditions. So first we look at the climatic conditions of Jabalpur. The temperature effect determines the efficiency performance of the PV systems. Below graph shows Jabalpur temperature condition throughout the year. According to the results obtained it is found to be suitable for local climatic conditions.

Climate in Jabalpur

The maximum and minimum temperature ranges between 46.6°C and 21°C respectively with mean relative humidity reaching up to 78%. The weather conditions as recorded at metrological observatory of JNKVV research station. Graphs of Fig. 4 refer the temperature data of Jabalpur. Efficiency of a solar panel is affected by irradiation and panel temperature. The solar radiation contains radiant energy as well as thermal energy, but PV power generation is only

Fig. 9. Testing of battery charging and discharging of solar sprayer with multimeter.

effected by the solar radiant energy. When the solar radiation rises on the cell, temperature also rises; hence the cell materials lose their efficiency. So, the avg solar insolation data was collected from gaisma website for the calculation of solar irradiation data (Weather data. https : //www.gaisma com/en/location/Jabalpur.html.).

Fig. 5 represents the climate conditions of Jabalpur during the year. The data was collected from the gaisma website. Chart represents sunrise, sunset, dawn, dusk times and sunshine length. The yellow gap represents sun shine length throughout the year. Base of chart roman line represents months of the year and right end of chart 1 to 24 represents time of day. The blue line represents dawn line and red line represents dusk line. The chart shows location's sunrise, sunset, dawn and dusk times for the everyday of complete year. Start of dawn and end of dusk times are based on the definition of "civil twilight". Dawn represents first appearance of light in the sky before sunrise. Example on the marked day (3) in Jabalpur dawn begins at 4:43 am; the sun rises at 05:37 am and sets at 21:20 pm. Dusk ends and the darkness begin at 22:14 pm (gaisma site).

Table 1 explains every month average irradiation data and average solar insolation of Jabalpur. From the Table 1 April month has maximum solar intensity and minimum solar intensity in August. The efficiency of the battery may be affected by the condition of under load where the solar intensity is not sufficient to generate the output of photovoltaic to meet the rated capacity. Hence, highest power generation is obtained in April.

Laboratory testing of developed sprayer cum weeder

Laboratory testing of solar and battery operated sprayer was conducted at College of Agricultural Engineering, JNKVV, Jabalpur to test different operating parameters like time taken for charging the battery with solar panel, time required for emptying the battery and simultaneous charging and discharging of battery with solar panel in working condition. By calibrating the machine spray application rate, volume rate can be found out. This information is necessary whenever you use chemicals that are specified in amounts per hectare. The spray application rate varies for different crops, different row spacing and the age, height and density of crops. This means you need to calibrate for each crop or block calibration ensures that you get good coverage of the target surface and that you spray the correct amount without wastage. Developed sprayer unit saves you time and money and results in a more effective and efficient spraying job and protects the environment.

Time required for battery charging with a solar panel of sprayer unit

The battery charging distinctiveness of push type solar and battery operated sprayer was studied to determine the charging time and rise in battery voltage while sprayer unit was in non- working situation. The solar photovoltaic panel was fully exposed to sunlight for battery charging. The various parameters like panel voltage, battery voltage, were measured. The variation of battery voltage, average voltage with time is shown in Fig. 6.

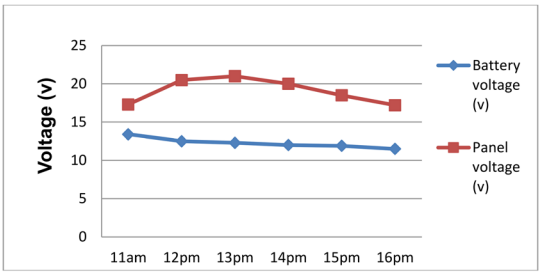

Fig. 10. Simultaneous charging and discharging of the battery in working condition of sprayer unit.

It was studied that the time required for charging of battery of 10.3 V starting at 11:00 am was found to be 1.80 h to achieve full voltage of 13.3 V. It was revealed that without solar photovoltaic panel, sprayer was operated only 1 h 30 min, which indicates the need of solar panel for continuous operation.

Battery discharging of sprayer in operating condition

The battery discharging characteristics of developed sprayer was studied to determine the discharge time of battery. The various parameter recorded during the testing are summarized in plate Fig. 7. The variation of battery voltage with time is shown in Replication-1, Replication- 2, Replication- 3 and Replication- 4 of Fig. 8.

It was observed that the fully charged battery (13.4V) of solar cum battery sprayer gradually reduces its voltage up to 10.3 V when it was connected to DC motor. Charge controller automatically stops dc motor when battery voltage becomes below 10.3 V. The average operating time of sprayer was found to be 1.50 h. It was revealed that the use of only battery as a power source reduced the efficiency of overall system due to gradual reduction in operating voltage.

Simultaneous charging and discharging characteristics of the battery with solar panel in working state

The battery charging and discharging characteristics of sprayer unit was studied to determine the total operating period of sprayer unit. The battery was charged with PV panel which was fully exposed in sun and simultaneously battery was used for operating the sprayer shown in Fig. 9. The battery voltage and panel voltage was measured shown in Fig.10. The maximum voltage from panel was 22 V at highest solar intensity and lowest voltage was 17 V.

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