Solar Operated Multiple Granulated Pesticide Duster

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ABSTRACT **- This paper illustrates invention and operation of multiple granulated pesticides duster with the use of solar energy. The concoction is accomplished by the use of solar panel, impeller type centrifugal blower, gear reduction mechanism, dispensers, D.C motors and batteries. In addition, the duster has been equipped with a facility to operate on an electric supply, which serves beneficial in the absence of sunlight. The device essentially works for disbursing solid granulated (powder) form of pesticide. The operator controls the rate and discharge of different pesticides by means of push buttons and toggle switches. The technical specifications of the device are worked and examined in a way to minimize the weight of the device and deplete the feeder unit dispenser in a span of three hours. The duster is portable, low cost device and emerges a boon for small scale agriculture, nursery, horticulture, and community services including farms.**

Keywords: **Pesticide Duster, Gear reduction, Impeller type centrifugal blower, Deep cycle batteries & Feeder unit dispenser, ANSYS 10.0**

I. Introduction

Duster is equipment which is used for spraying insecticides, pesticides, and fungicides. An agriculture duster is a duster that has been built or converted for agricultural use usually for aerial application of pesticides (crop dusting) or fertilizers (aerial to dressing). Dusters (sprayer) have become an indispensible for high productivity and have contributed to the worldwide crop production revolution. Dusters cover a wide variety of agricultural jobs and pest applications, including control of competing weeds and unwanted bushes and trees, control of diseases and insects, application of plant nutrients, and broadcasting of many crops.

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A pesticide may be a chemical substance, biological agent (such as a virus or bacterium), antimicrobial, disinfectant or device used against any pest. Pests include insects, plant pathogens, weeds, mollusks, birds, mammals, fish, nematodes (roundworms), and microbes that destroy property, spread disease or are a vector for disease or cause a nuisance.

Conservation of non-renewable resources with an objective of attaining sustainable developments has lead to an incredible advancement in both understanding and employing sun's vast energy to benefit mankind. The advent of photovoltaic modules and arrays or simply solar panel corroborates this progress. The photovoltaic (PV) or solar cells crafted from silicon semiconductor are configured to trap and convert the sun's energy into useful energy, which is then used to perform work. Hence, the optimum exploitation of sun's energy is used here to drive out a duster. The duster eliminates the conventional style of hand spraying powder pesticide, thereby reducing hazard of diseases and saves time.

II. Literature Survey

Aircrafts are also used for spraying and dusting. The principle advantage of aircraft for the treatment of crops lies with their ability to cover large crop areas and to travel over rough terrains, irrigation structure, and wet fields. The primary disadvantage is their inability to direct and release material onto the target crop with precision that can be accomplished with ground based application. Increasing limitations are being placed on the aircraft usage, especially when highly toxic chemical are to be applied in small fields, and where sensitive target crops are grown nearby.

Pressurized liquid/gaseous portable back strap type pesticide sprayers have been developed to reach the target crop. The conventional pesticide duster [1] has a separate cartridge wherein powder pesticide is fed and mixing of this powder with fluid occurs in the cartridge chamber. Timely removal and refilling of cartridge is required and the simultaneous disbursement of different pesticides appears as a shortcoming in the duster.

The emphasis here is hence laid on the usage of a duster for spraying different kinds of powdered form of pesticide from a single device incorporating the use renewable source of energy. The need of the cartridge chamber is also eliminated in the present case.

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III. EXPERIMENTAL

Fig. 1, portrays the provisional setup of the multiple pesticide duster operating on solar energy.

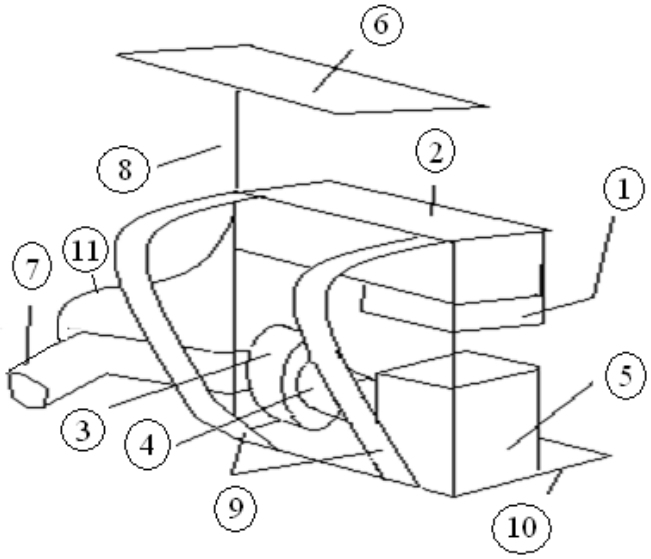

Fig. 1: Solar operated multiple granulated pesticide duster

The duster comprises of charging module **1** which has electrical circuits and electrical components, required to drive the duster. The module has three ports which are respectively connected on one side to the terminals of three batteries **5**. The other sides of ports are having detachable pins connected to electric supply, blower motor **4** and solar panel **6**. The required pins can be inserted into ports whenever necessary so that the electric supply pin and solar panel pin can charge any of the three batteries. The blower pin can then be inserted into any of the three ports of batteries provided the batteries are charged so that they can discharge current required to drive the blower unit.

The duster comprises two sections namely, the blower unit **3** and the feeder unit – dispenser **2**. The blower unit is made using 6mm MDF sheet. One sheet supports the blower motor while other sheet with a central hole is made for air inflow. The blower impeller is made of polyvinylchloride (PVC). The feeder unit – dispenser consist of pesticide container that incorporates 2V DC motor coupled with a 100:1 reduction ratio gearbox. The output shaft of the gearbox is connected with a plastic shaft at the end of which a worm gear is fixed. The worm gear and the container have a gap in between for flow of powder from pesticide into the air flow. The needles on the plastic rod are meant to whirl the settled powder because of flow of powder from pesticide can be maintained through the blow pipe **7**. To adjust the height of the solar panel above the head, retractable link **8** is provided. The whole unit can be carried conveniently at the back of human body with the help of shoulder straps **9.** The supporting base of the entire unit needs to be strong and lightweight. Keeping in mind the stress analysis and force acting at various sections, an aluminium frame **10** is used. The aluminium frame can also be replaced with acrylic enclosure.

The solar panel and the external electric supply are used to charge a deep cycle battery. The number of times a battery can be discharged is known as its cycle life. For solar applications, a battery should be capable of being discharged hundreds or even thousands of times. In such cases a deep cycle battery is used. In this case, a lead acid accumulator serves the purpose. The technical specifications for particulars, required to drive the duster unit are shown in Table I. The specifications considered are temporary and subjected to change depending upon the usability and complicacies of the area and work undertaken .

Table I: Technical Specifications of different components required to form multiple pesticide duster.

S.No	Particulars	Specifications
1	Solar Panel (Crystalline)	3 watt, 6 volt, 500 mA
2	Blower Speed	1440rpm
3	DC motor for blower	1440 rpm, 8 watt
4	DC motor for feeder mechanism	2500 rpm, 1 watt
5	Gear ratio	100:1
6	Battery(3)	6 volts (each)

With the help of toggle switch the main blower motor is made ON and OFF while the pesticide feeder motor is switched ON and OFF using the push button. The pesticides are blown whenever required, by pressing the push button. This enables the worm gear into motion which ultimately pushes the pesticide into the air flow. Duster takes in power from 6 V batteries connected in series thereby making it rotate on 12V DC, while the pesticide feeder motor runs on 6V DC. Thus the equipment uses the solar energy by means of solar panel and this energy is stored in form of chemical energy in the batteries which is then converted to electrical energy required to run the D.C motors intern running the centrifugal blower. The rotation of the impeller causes pressure difference at the inlet and outlet of the blower which is responsible in causing air to rush in through inlet and discharges at outlet. In the flow of air, pesticides are then dispensed through feeder mechanism and switches. The outlet of the dispenser unit is then attached with a flexible hose pipe to enable the operator to spread pesticide according to his/her own will. The maintenance of the duster is restricted to the cleaning up of its various components and life of the battery.

IV. DESIGN

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A. Design of Base Frame

A rectangular frame of aluminium is having square cross section of 2.5*2.5 cm^2 of length 35 cm having loads values as shown in Fig. 2.

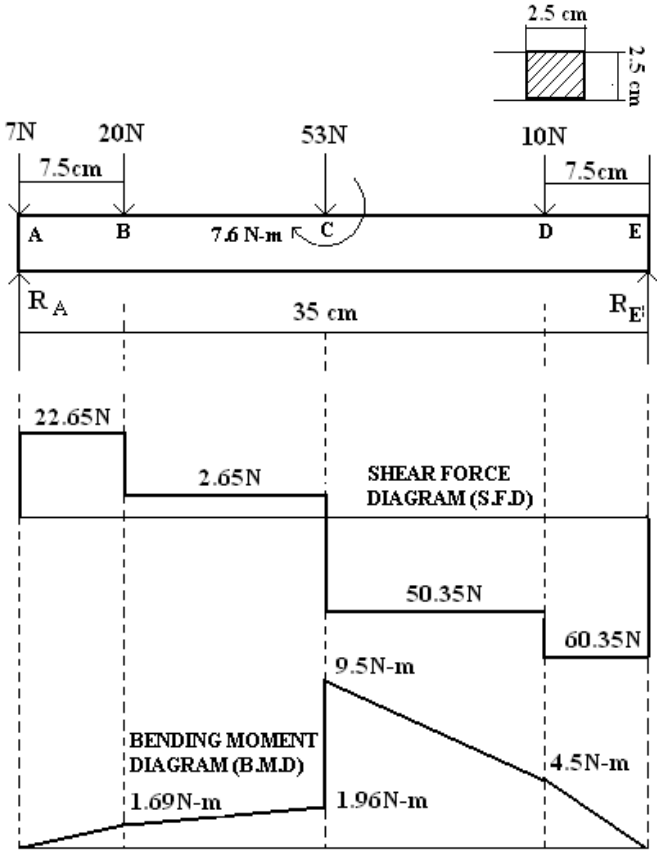

Fig. 2: Shear force diagram and Bending moment diagram of base frame

Determining reaction at the supports

$\sum F_x = 0$; $\sum F_y = 0$

Referring fig. 2 let R_A be the reaction at point A and R_B be the reaction at point B.

Therefore considering $\sum F_y = 0$.

$R_A + R_E - 20 - 10 - 53 - 7 = 0$

$R_A + R_E = 90N$ --- (1)

Taking moments @ A; $\sum M_A = 0$

$0.35R_E - (10*0.275) - (53*0.175) - (7.6) - (20*0.075) = 0$

$R_E = 60.35N$

Using equation (1) $R_A = 29.65N$

The Share force Diagram (S.F.D) and Bending Moment Diagram (B.M.D) are drawn as shown in fig. 2.

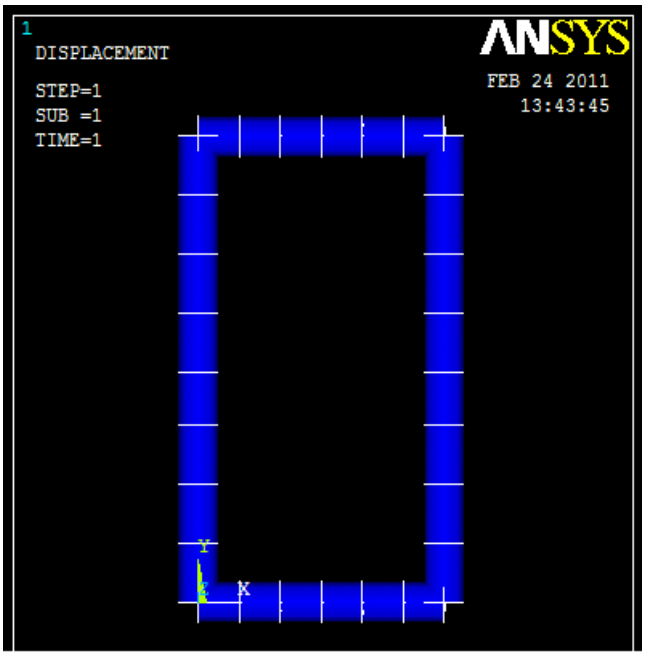

Fig. 3: Deformation diagram on ANSYS 10.0

Considering B.M.D

$\sum M_E = 0$

$\sum M_D = 4.5265N\text{-}m$

$\sum M_{Ca} = 9.5N\text{-}m$ $\sum M_{Ca} = 1.96N\text{-}m$

$\sum M_B = 1.69N\text{-}m$ $\sum M_A = 0$

Therefore the maximum bending stress (S_b) will be

S_b = B.M. $_{(max)}$ / section modulus (Z) ---(2)

Section modulus (Z) = $bd^2/6$

$= (0.025)3/6$

$= 2.604 * 10\text{-}6\ m3$

The maximum bending moment value is 9.5 N-m

$S_b = 9.5/(2.604*10\text{-}6)$

$= 3.65$ MPa ---(3)

The ultimate stress value for aluminium is 70MPa [2]. Aluminium is a soft metal. Thus 6 is chosen as the value for factor of safety [2]. The safe stress value of a material is equal to ultimate stress value by factor of safety.

Safe stress value for aluminium = (70/6) MPa

= 11.67 MPa ---(4)

Comparing the values of maximum bending stress from eq.(3) and the safe stress value for aluminium from eq. (4), we find that the value of maximum bending stress is less than safe stress value. Hence the design is SAFE. This has also been

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verified by Finite Element Analysis (FEA) software called ANSYS 10.0. The deformation diagram is shown in fig. 3. The blue color in Fig. 3 indicates that the designed frame will not fail under the application of the considered load.

B. Circuit Design

The electrical circuit required to charge the duster batteries through electric supply is shown in Fig.4.

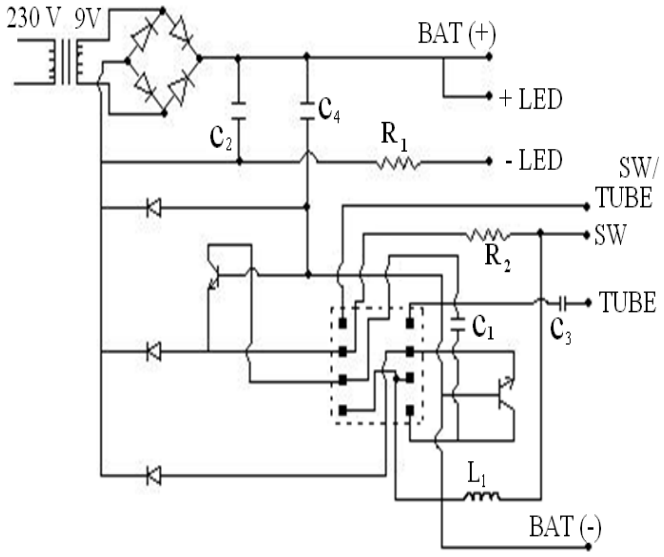

Fig. 4: Electrical Circuit Diagram showing charging of batteries through electric supply

C. Flow Rate Measurement

Fig. 5 show an acre of land which cultivated with plants placed at a distance of 2 feet from each other.

Now 1 Acre = 4840 sq.yards

1 Yard = 3 feet

1 Area = √4840 = 69.57 * 69.57 sq.yard

Conversion of yard in to feet = 69.57*3 = 210 feet

Therefore Area in Feet = 210*210 = 44100 sq. feet

Speed of Dc Motor for feeder mechanism = 2500rpm.

With the help of Gear Reduction Box; speed is reduction is shown as below:

Gear Ratio = 1:40 – worm and worm wheel

$G = N_1/N_2 = 40$

N_1 = 2500rpm (Given)

Hence N_2 = (2500/40) = 62.5 rpm = (62.5/60) = 1.041 rps

Assuming Separate Reservoir Capacity = 20 kg

Assuming that distance between each crop = 2 feet

Hence Total No. of crops in one Acre = 105*105 = 11,025

Amount of Insecticide per crop = (20/11025) = 2 gm

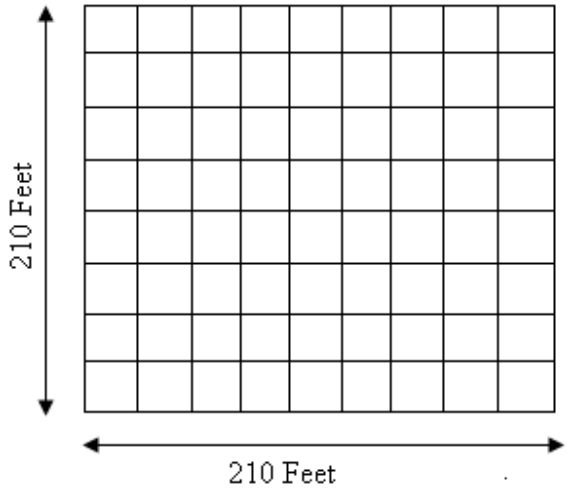

Fig. 5: Plants cultivated on an Acre of land at a distance of 2 feet from each other

Assuming Spray Rate = 2gm/sec

Considering per sec rate for each crop

Time required = 11,025sec = 11025/3600 = 3 hours

Hence Spray of pesticide having rate of 2gm/sec at a worm speed of 1.041rps in 3 hours is practically possible.

D. Determination of number of Batteries

Battery backup is needed to drive the pesticide duster for three hours as calculated during the flow rate measurement. The number of batteries required, are calculated by considering energy provided by a single battery and energy required to run different components as explained below:

At Input: Consider 'N' batteries

Energy (E) for a batteries = V*I*t/2

= 6*4.5*3600/2

= 48,600 J

At Output: Blower power = 8 watt

Feeder Motor power = 2 watt

Total power = 10 watt

The total energy at input is not always equal to total corresponding energy at output. Hence considering efficiency as 90%, the actual power at output is 0.9*10 = 9 watt

Energy = Power * time

= 9*3*3600

=97200 J

Now number of batteries N = Energy (output)/Energy (input)

Therefore N = 97200/48600

N = 2

Thus batteries required are two in number for operating the pesticide duster for 3 hours. As an additional back up we can consider the three batteries required to drive the duster.

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V. Duster Economy

Table II shows the economic viability of the pesticide duster with cost estimation of all the major components required to drive the unit in Indian Currency.

Table II: Approximate cost analysis of duster unit

S. No	Component	Quantity	Cost per unit (Rs.)	Total Cost (Rs.)
1	DC motor for blower	1	625	625
2	Small DC motor	2	90	90
3	Gear box	2	575	1150
4	Solar panel	1	1650	1650
5	Blower	1	450	450
6	PVC sheet	1m	175/m	175
7	Battery	3	170	510
8	Aluminum Frame	2kg	200/kg	400
9	CFL circuit	1	300	300
	Total Cost			Rs 5350/-

VI. Conclusion

A temporary model of the designed pesticide duster is shown in Fig. 6.

Fig. 6: Temporary working model of solar operated granulated pesticide duster

1. The maximum bending stress value is smaller than the safe stress value of the material (Aluminium) considered. This substantiates the fact that the frame would not fail under the conditions of load considerations and the design is safe.
2. There is no running cost associated with the duster. The maintenance cost is only restricted to life of battery and PV module. No requirement of skilled operator. The duster is very economical in case of mass manufacture of the entire unit.
3. The flow rate calculation demonstrates the optimization of output flow rate of pesticide duster within time constrains.
4. In case of unavailability of sunlight, the duster batteries can be charged by electric supply. The need for handling long electric cable to drive the duster is eliminated which makes it portable to use.
5. The duster prevents biological hazards of spraying powder pesticide by means of conventional methods. Micronutrients can also be dusted with the help of it.
6. The duster is highly economical and can be used on small land area to large fields.

Acknowledgment

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