DESIGN OF AUTOMATIC PESTICIDE SPRAYING MACHINE

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Abstract: A different type of pesticides spraying machines is available in India. Most used machines are backpack sprayer used by farmers because of its easiness to use and cost effective. But farmer spraying pesticides are harmful for their health and also result into a muscle strain due to weight of equipment. These methods take too much time and also deleterious to human health. The aim of the project is to make wireless machine, operated by a remote control device at any desire distance within the certain limit without any interaction with the pesticide and also sprayed with minimum effort.

Keywords: automatic pesticide spraying machine, DC motor, Nozzles, pesticides

I. Introduction

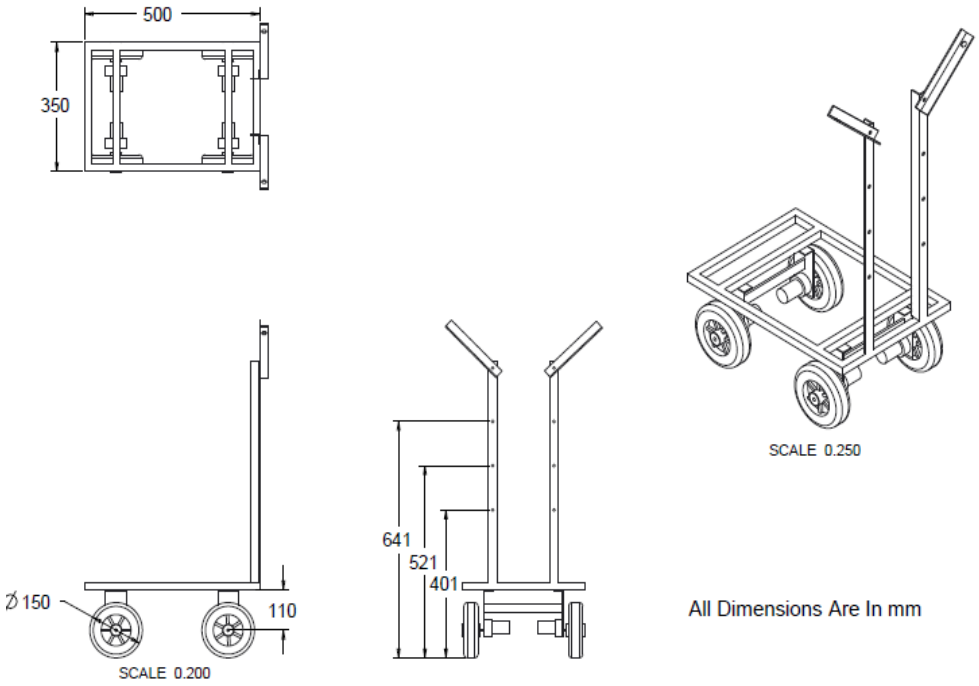
India is a land of different crops; nearly 55% peoples live in villages and their source of livelihood is farming. Still, they are not producing crops with required quantity and quality due to lack of proper utilization of technology. They still use traditional methods like bag-pack sprayer, spraying powder pesticide manually. This is deleterious to human health and also improper utilization of pesticide.

Our idea of the project is to prepare a machine which operates different equipments, operated by a wireless remote device and generated power from the battery. A pipe is extruded from a tank in which pesticide is stored. This pipe is diverging into two parts by T- connector which is connected to the nozzles. Due to such arrangement pesticide is sprayed on both the sides accurately as per the requirement.

II. Objectives

- Our main objective is to design and fabricate automatic pesticide spraying machine.
- A model running without any fuel and also easy to operate for the user.
- Even though the initial cost might be high, but it would be far more profitable on a long term use.
- Increases the efficiency of spraying.
- Removes the backpack and foot spraying techniques.

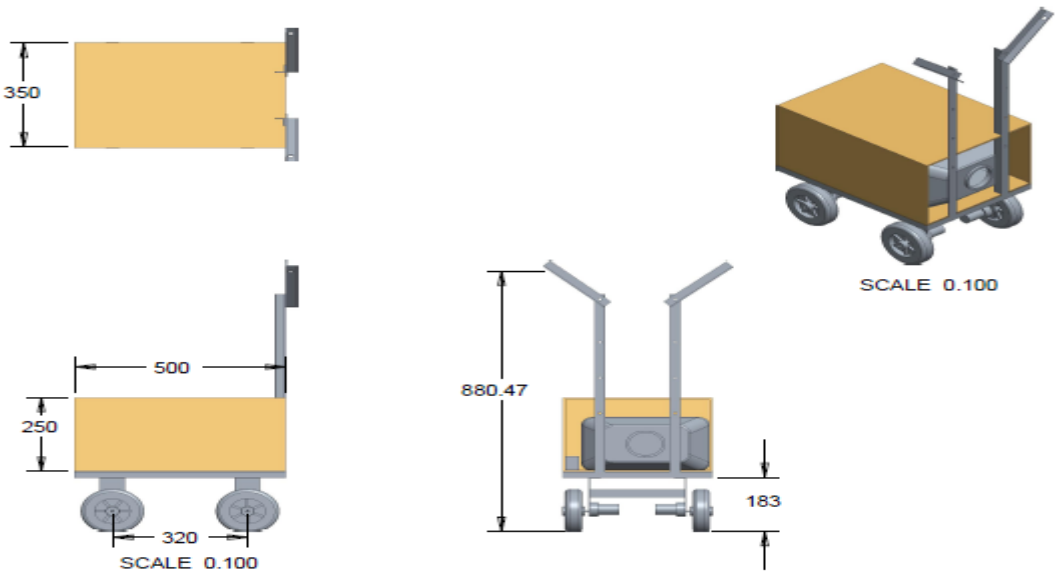
III. Construction and its Working



The machine consists of the main body frame; battery, DC motor, nozzles, pipes, wheels, tank and DC pump which is a 4 wheel drive machine for ease of off-road driving ability. The driving wheels of the machine are driven by 4 planetary geared 12V DC motors. The design of the frame being such that it is as lightweight as possible without undermining the strength of the frame. The tank placed on the machine containing pesticide which is then pumped with the help of a water pump with good water transfer capacity and max spraying height capabilities. The pesticide is then sprayed to the crops with nozzles which is the main device in any spraying machine. The tank is kept at the center of the body to maintain the CG of the machine while the battery being at the back along with other electrical circuits and the pump along with spraying component at the front. All the electrical circuits then being safely covered to avoid any incident of pesticides damaging the circuits and its wirings. The remote is used to operate the vehicle, the range of remote being 50m sends signal to the available circuit board in the market which controls the movement of DC motors in a way without the need of a steering mechanism hence reducing the weight and cost of the machine.

The power source to run this machine is DC Battery. 200 RPM DC Motors are directly attached to the wheels runs on battery. Also DC Pump runs on the battery. When a vehicle moves forward, the liquid discharge from the tank by the pump. Here we are using 2 nozzles so we can maintain the required amount of pressure. The liquid pesticide from the tank is sprayed to the plants via nozzles. Nozzle angle for spraying is 90 degrees in order to cover large areas. Thet tank is adjusted such that the robot has the low CG which in turn increases stability. The battery and other electronic components are placed alongside the tank which is completely covered by wooden box to avoid any contact between the pesticide, wires and electronic parts.

IV. Dimensions



V. Components

1. **Frame:** It is the chassis part on which clamps for motor, supporting plate, vertical supports for the nozzles, battery, pump, and tank are attached. It is made up of mild steel. Its specifications are as follows:
   a.) Material: Mild Steel
   b.) Length: 500 mm
   c.) Width: 390mm
   d.) Cross Section: 20*20 mm
   e.) Thickness: 2mm
2. **Motor:** Motor is use to drive wheel in different direction. Its specifications are as follows:
   a.) Gear Box Diameter: 50mm
   b.) Motor Diameter: 35mm
   c.) Shaft Diameter: 8mm
   d.) Length without Shaft: 50mm
   e.) Shaft Length: 25mm
   f.) Weight: approx. 150gm
   g.) Torque: 20kgcm
   h.) Base Motor RPM: 300RPM
   i.) 200RPM 12V DC motor with Metal Gearbox and Metal Gear
3. **Wheels:** wheels are used to drive the machine. Its specifications are as follows:
   a.) Tracked wheel for dc motors
   b.) Material: Polymer plastic
   c.) Outer Diameter: 150mm
   d.) Hole Diameter: 8mm
   e.) Bush with hole (MS)
4. **Pump**: It pumps pesticide from tank to the nozzle with the desire amount of pressure. Its specifications are as follows:
   a.) Dual core power pump
   b.) Model No.: DP-1038
   c.) Max. Pressure: 105PSI (7.2Bar)
   d.) Max. Flow: 330LPH
5. **Battery:** Motor is the main power source of the machine as it powers the wheels and pump which spray pesticide on the crops. The motor mainly used is a 12V DC motor with 7AH capacity or more. Battery is recharged in approx. 1-2 hrs and is again ready for use. The specifications are as follows:
   a.) company name: Silverline Agritech battery
   b.) 12V 7AH Capacity
6. **Nozzles:** A nozzle is a device use to spray the liquid with desire amount of pressure and velocity in required direction. It has different cross-sectional area according to required direction, mass and velocity of spray. In a nozzle, the velocity increases with the decrease in pressure energy.
7. **Arduino Mega:** The microcontrollers are typically programmed by C and C++ languages using his dialect features. Arduino board receives signal from remote controller and the board converts signals to voltage pulses which results in the movement of machine with combination of all motors performs forward, backward, left and right. The specifications are as follows:
   a.) ATmega2560 microcontroller
   b.) Input Voltage: 7-12 V
   c.) 54 Digital I/O Pins
   d.) 16 Analog Inputs
   e.) 256k Flash Memory
   f.) 16MHz Clock Speed
8. **Drivers:** It is used to drive the moving parts by its connections with Arduino and the controller. Its specifications are as follows:
   a.)6V-18V compatible 20A capable dual DC motor Driver
   b.)Simple connectivity with IO pins of any MCU
9. **RC Transmitter with Receiver:** It is a component used to operate the device from a distance, usually wirelessly. Flysky FSi6 is an economical and high quality 6 Channel radio with FS-iA6B 6 channel receiver. Its range is about 1km. It can also be loaded with custom firmware to convert it to 8 Channel systems when used with PPM output in receiver. It's extremely power efficient and works for upto 10 hours when used with 4 alkaline AA cells.
   a.) Channel: 6 (10 with modified firmware)
   b.) Model Type: fixed wing/helicopter/glider
   c.) RF Range: 2.405 - 2.475GHz
   d.) Bandwidth: 500khz
   e.) RF Power: less than 20dBm
   f.) RF mode: AFHDS 2A

g.) Modulation type: GFSK
h.) Channel resolution: 1024 steps
i.) Low voltage warning: less than 4.2v

10. **Tank and Connecting parts:** Tank is used to fill the pesticide of required quantity with maximum capacity of 20 litres. Other connecting devices are t-joint and pipe, which is used to join the tank with pump and the nozzles. It also includes wires for the electric coupling between the different components to make an electric circuit.

Cost Estimation

Name	Prices per nos.	No. of nos.	Total price
Frame+ Fabrication	3100	1	3100
Motor	1350	4	5400
Wheel	170	4	680
Pump	1500	1	1500
Nozzles	100	2	200
Battery	900	1	900
Arduino processor	750	1	750
Driver	840	1	840
Controller	1500	1	1500
Tank and other connecting parts	470	1	470
Total	-	-	15340

VI. DRIVE WHEEL MOTOR TORQUE CALCULATION

When we are selecting the motor of required maximum torque, number of factors is to be considered. They are as follows:

Different criteria:

- Gross vehicle weight (GVW): 40kg
- Weight on each wheel (W_W): 10kg
- Wheel radius (R_w): 6in =0.152m
- Top speed (V_{max}) : 2m/sec (desired)
- Acceleration time (t_a): 1 sec (desired)
- Max. Inclination angle (α): 35 degree (Assume)

Worst working surface: Mud (medium)

Now we have to calculate the total tractive effort (TTE) required for the vehicle in order to choose the motor of required torque:

$TTE = R_R + G_R + F_A$

Here:

- TTE = total tractive effort
- R_R = force necessary to overcome rolling resistance
- G_R = force required to climb a grade
- F_A = force required to accelerate to final velocity

Now we have to calculate the different components of the above equation. The calculation is as follows:

Step One: To determine rolling resistance

Rolling Resistance (R_R) is the force necessary to propel a vehicle over a surface. The worst conditions encountered by the vehicle on different surfaces are taken in consideration.

R_R = (a+bV) W, N

Where: R_R = rolling resistance

W = weight of vehicle

V = velocity of the vehicle (2m/s)

a, b= constants

a =0.0112

b =0.00006

R_R = [0.0112+ (0.00006*2)] (40*9.81)

= 0.01132*392.4

= 4.56 N

Step Two: To determine grade resistance (G_R)

The amount of force necessary to move a vehicle up a slope or grade. Here we have to take the value of the inclination angle into the equation.

Gradient resistance:

$$G_R = W \sin\alpha$$

Where:

G_R = gradient resistance

W = vehicle weight

α = max. Inclination angle [degrees]

G_R = 40 x sin (35°)

= 22.94 N

Step Three: To determine acceleration force

Acceleration Force (F_A) is the force necessary to accelerate from rest to maximum speed in a desired time.

$$F_A = \frac{W\ [kg] \times V_{max}\ [m/s]}{(g\ [m/s^2] \times t_a\ [s])}$$

Where:

F_A = force of acceleration

W = weight of vehicle

V_{max} = max. Speed

(t_a) = time required to achieve max. speed

$$F_A = \frac{40 \times 2}{(9.81 \times 1)}$$

= 8.15 N

Step Four and Five:

Step Four: To determine total tractive effort

The Total Tractive Effort (TTE) is the sum of the forces calculated in steps 1, 2, and 3.

$TTE = R_R + G_R + F_A$

TTE = 4.56+22.94+8.15 = 35.65 N

Step Five: To determine wheel motor torque

Now we have to calculate the required torque (T_w.) in order to verify that the vehicle will perform according to tractive effort and acceleration.

$T_w = TTE \times R_w$

Where:

T_w = wheel torque [Nm]

TTE = total tractive effort [N]

R_w = radius of the wheel/tire [m]

$T_w = TTE \times R_w$

= 35.65*0.152

=5.419N.m

Torque on each driving motor = total torque/no. of motor used

= 5.419 /4

=1.355N.m

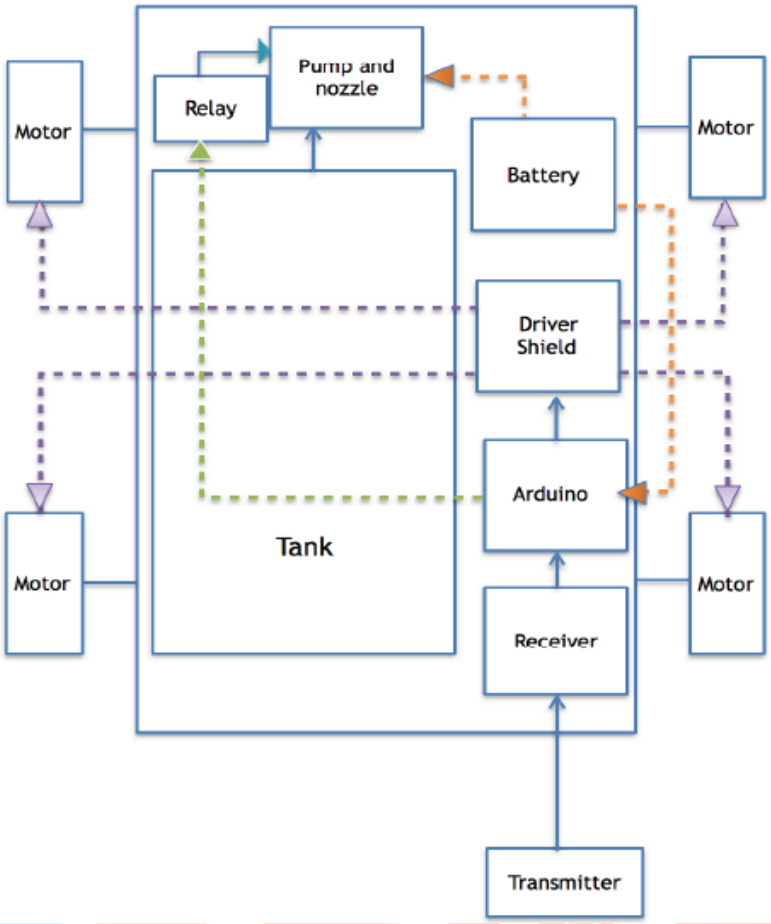
=**13.817kgcm**

So we are using motors with torque of 20kgcm in order to avoid any problem

VII. Experimental Results

1. **Number of Wheels:** First we decided to make a 3 wheel vehicle. But due to this the required traction is not obtained and the vehicle began to slip. So at last we decided to use 4 wheels.
2. **Number of Motors and type of drive:** First of all, we were using 2 motors on the rear side to make it a rear wheel drive. But when we do our first test to run on the uneven ground its results into the stoppage in motion if any one of the wheel if got fixed or slips in the mud portion. As a result, we decided to make it 4 wheel drive so that if any of the wheels got struck, we can use the other wheels.
3. **Motor shaft:** Here due to the weight of the components and tank filled with pesticide placed on the platform results into the bending of the motor's shaft. So we use two supports which provide us the support against the bending of the clamp along with the shaft of the motor.

VIII. Methodology



IX. Physical Model

X. Conclusion

The model of wireless pesticide machine is successfully fabricated by our team. Here we used 4-wheel drive to give it smooth motion along with the high initial torque. There is no usage of the fossil fuels to run the machine. The model is simple and can be made easily without much effort.

We have some limitation in the alignment of the wheel as manual welding results into the difference in the amount and place of welding. There is also a limitation of the fixing of the wheel with the motor as the screw from the wheel bush only attached to the motor shaft by simple load. This can be prevented by providing proper screw and nut system between the wheel and motor.

XI. Acknowledgement

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