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3-Wheel Electric Vehicle for Multiple Spraying Purpose

Nishantkumar V. Patel[1], Sachin Ranpariya[2], Dipkumar Patel[3], Mitul Malli[4], Bhaumik J. Sheth[5]

[1,2,3]Students of Department of Mechanical Engineering
[4,5]Assistant Professors in Department of Mechanical Engineering
[1,2,3,4,5]A. D. Patel Institute of Technology, Anand, Gujarat, India.

Abstract- *Since last few decades, diverse pesticide and disinfectant spraying methods have been used in Indian farming and health sector. In current agricultural scenario, backpack-type sprayer are predominantly used in agriculture fields as such kind of sprayer has low initial cost and easy to use by operator on site. In contrast, this conventional method requires a lot of time, possesses high operational cost as labor cost, and also the farmer or person who is spraying pesticides have got adverse effects to health as pesticides liquid contains toxic contents as well as body pain to operator due to weight of that whole sprayer system. Whereas municipal corporations and government health centers do use sprayers which have high initial and running cost. Therefore, in order to eradicate these problems, shifting of adaptation from traditional spraying technique to the typical electric pesticide and disinfectant spraying machine needs to be take place which could be proved as a welfare option. Fulfillment of this objective is the motive of project work by elaborating the different topics and developing appropriate machine for mentioned purposes.*

Key Words: **Fluid (Pesticides & Disinfectants), Nozzle Discharge, Vehicle or Rover, Vehicle Velocity, Efficiency, Efficacy, Agriculture and Health Sector.**

1. INTRODUCTION

India is a country where nearly 70% of people lives in rural and remote province and main source of their income is farming and its related works. Apart from that, crop-reaping at the end of its season is ubiquitous in India and storing can be easily done through storage rooms and halls. Besides this, farmers do not produce the enough amount of crops of which they actually having the ability to grow. Reason behind it is Indian people who all related to agriculture are not implementing and following the proper farming technologies and work efficient products. They have a lack of access to adopt the updated farming machineries and products. So, it should be necessary to have the machines that can help cultivators to save their time and money and to increase the production rate, and ultimately to empower the nation with better agricultural-economy. We have to make economical tools that fall under the affordable price range so farmers can easily purchase it. The introduced spraying assembly could establish the good aspects like time and money saving to the farmers and its users.

Not only this machine could be use in the realm of agriculture but immensely useful for spraying and sanitizing the disinfectants in the critical time of epidemics like COVID-19, Swine Influenza (H1N1), or any other infectious diseases, so this concept would be going to act as an important feature in health sector too.

2. PROBLEM DESCRIPTION

Nowadays, no wonder there are many types of pesticide sprayers available in India. But mostly used sprayer is backpack type sprayer which are used by lot of farmers because it is cheaper, easy to utilize. As a result, such conventional methods could lead to health hazards and may cause damage to crop due to improper distribution of pesticides. So, such problems often take place in backpack type sprayer or in other traditional spraying methods.

Firstly, cultivators are often facing the problem of the improper Distribution of Pesticides. Further, the improper distribution of pesticides leads to the poor crops and consequently the rectification of bad crops to make good-developed crops the other expenses will increase. In addition to this, the proper maintenance of crops lead to excessive labor charge. Sometimes the overdose-sprinkling of pesticides may burn the crops.

Secondly, the Poor Working Conditions expose some people to dangerous concentrations of pesticides. Farmers, forestry, and public park workers may contact with pesticides in their professional environment. Thousands of cases of pesticide poisoning are registered every year. Risks of poisoning depend on toxicity and period of exposure. Pesticides may cause neurological and psychiatric complications, by birth defects. Pesticide exposure is damaging to the immune system also.

Municipal workers, guardians, hospital-staff have difficulties in sanitizing the streets, hospital wards, public areas by the numerous existing disinfectant spraying methods. They face the issue of high demanding physical-work-load, and this occur due to low amount of disinfectants spread in targeted places which usually takes

high period of time. So, sanitization requires large amount of time by currently used spraying methods.

3. ADVANTAGES OF PROPOSED MODEL

The proposed spraying method has an ability to eliminate the pre-described problems in previous section, and have advantages over the existing spraying methods in terms of time period, physical work-load, cost or labor charge, machine efficiency and efficacy.

First factor is 'Time-Period ***(T_p)***'. Existing spraying methods like backpack type sprayer takes too much time to spray the pesticides over the working field where as proposed rover takes less time period because of multiple (4) nozzles are working during spraying task. Due to the advantage of multiple number of nozzle, the total amount of flow output of pesticides is very high as compared to the flow output of other methods.

Second is 'Physical Work-load ***(L)***'. Physical work load in the form of back and shoulder pain can been frequently seen in backpack type sprayer as tank is fitted behind the back of working person. While, in case of proposed sprayer a tank is not mounted on back side. In addition, worker's hands are in working whereas the nozzle bars are so adjusted horizontally or vertically according to the geometry of crop, infected public spaces and public streets. Ultimately, this factor can be reduced by the utilization of such spraying rover.

Third factor is 'Cost or Labor Charge ***(₹)***'. Cost is very important factor to the farmers and municipalities. Indian agricultural labor community has a raw standards of taking wages, and wages depends upon the aspects like how much demanding the physical work is and how much time the spraying operation takes. Therefore, cost factor simply has a directly proportional relation to previous 2 factors.

$\therefore (₹) \propto (T_p)$
$\therefore (₹) \propto (L)$

Fourth is 'Efficiency ***(η)***'. Efficiency is the productivity of machine. Here the efficiency of rover can be defined as the total output flow through all nozzle per unit time. In backpack sprayer there is only single nozzle available, subsequently the output flow is low or one fourth of the output flow of 3-wheel vehicle sprayer.

$\therefore$ *Efficiency of Backpack sprayer* $= \eta_1$

$\therefore$ *Efficiency of Vehicle sprayer* $= \eta_2$

$\therefore$ *Discharge of Backpack sprayer Nozzle* $= Q_1$

$\therefore$ *Total Discharge of Vehicle's Nozzles* $= Q_2 = 4*Q_1$

$\therefore$ *Time period for Backpack sprayer task* $= T_{p1}$

$\therefore$ *Time period for Vehicle sprayer task* $= T_{p2}$

Suppose time period required to complete the one spraying task for vehicle or rover sprayer is half of the time period taken by the backpack sprayer. That means,

$\therefore T_{p2} = (T_{p1}/ 2) = (0.5T_{p1})$

Efficiency(η) can be defined as the nozzle discharge of fluid per unit time or spraying operation time.[$\therefore \eta=(Q/T)$]

So, efficiency equation for both methods would be like below,

$\therefore \eta_1 = (Q_1/ T_{p1})$
$\therefore \eta_2 = (Q_2/ T_{p2})$
$\therefore \eta_2 = (4*Q_1/ 0.5T_{p1})$
$\therefore \eta_2 = 8*(Q_1/ T_{p1})$

$$\therefore \eta_2 = 8*\eta_1$$

Hence, the proposed spraying method's efficiency (η_2) is higher than efficiency of conventional spraying methods (η_1). Further Efficiency (η) analysis is shown in the fluid mechanics calculations.

Fifth one is 'Efficacy ***(σ)***'. It is basically the effectiveness and how well the fluid spraying is done. Nozzle bar positions and nozzle spray distribution plays huge role in this factor. Nozzles used in this machine has fine conical spray distribution. Also due to the more number of nozzles the fluid distribution covers more spaces. Two nozzle bars are free to stay statically in vertical or horizontal positions. Apart from that, the longitudinal movement can also be done onto the nozzle bar for better personalization. Therefore, if crop geometry or shape is complex one can easily make the effective spraying operation with such modifications of nozzle and nozzle bar positions. Table-1 shows comparison between two spraying methods.

Table -1: Factors Comparison Table

Factor (for single no. of spraying task)	**Conventional Spraying Machines**	**Proposed Spraying Machine**
Time-Period (**T_p**)	More ↑	Less ↓
Physical Work-load (**L**)	High ↑	Low ↓

Cost/Labor Charge (₹)	More ↑	Less ↓
Efficiency (η)	Low ↓	High ↑
Efficacy (σ)	Low ↓	High ↑

4. WORKING PRINCIPLE

The battery is connected to 3 electrical devices- DC motor and two electric pump through wires. When the power supply is on battery provides current and voltage to motor. DC motor is start to rotate. The mechanical rotational power of motor transmit to the wheel through the particular powertrain elements. The motor output is connected to first chain sprocket then this chain sprocket is starting to rotate the roller chain then after to shaft and at the end power transferred to the wheel. So, these working components complete the phase of displacement of rover.

Besides, at the same time two electric pump have came into action. At the inlet port of pump the suction of fluid takes place from tank through pipes. Afterwards, both pump pumps the fluid from outlet or delivery port to different nozzles.

At the end, four different nozzles convert the continuous flow of fluid into atomized-distributed flow. So, for this case the process of spraying is done. Basically, the Model is working on the principles of Fluid mechanics and electromechanical systems.

5. COMPONENTS & SPECIFICATIONS

a.) **Chassis**: Chassis is used to act as a body frame of whole assembly of vehicle. It holds the all other physical components.

Material- Cast Iron
Weight- 6.5 kg
*Dimension(l*w*h)= 0.80*0.30*0.42 m*
Color- Black

b.) **Wheel:** Tubeless tire is used to make the displacement of the rover onto the working field.

Tire Type- Tubeless
Tire Material- Plastic-type Rubber
Rim & Spoke Material- Stainless Steel.
Wheel Diameter- 0.390 m

c.) **Electric DC Motor:** This DC motor provides the rotational power to wheel through the powertrain which is containing the chain drive and shaft.

Motor Type- DC powered, Servo Motor
Current- 8 A
Voltage- 12V
Speed (On-Load)- 40±42 RPM

d.) **Electric Pump:** This device is added to deliver the fluid from tank to nozzle under the defined pressure value.

Current- 3.4 A
Pressure- 135 PSI = 9.3 bar
Flow- 6.0 LPM (Liter per Minute)

e.) **Tank:** This component is used to store the fluid whether it is pesticides, disinfectants or water.

Material- Plastic
Storage Capacity- 15 Liters

f.) **Rechargeable Battery:** The battery is used to provide the electricity to pump and DC motor.

Battery Type- Rechargeable
Current- 12 Ah
Voltage- 12 V

g.) **Chain Drive:** Chain drive is the first element of powertrain/ power transmission system. Basically it consists of two parts. First is, 2 Chain Sprockets. Second is, Roller Chain.

Material- Cast Iron and Alloy Steel
No. of Tooth on Sprockets- 14

h.) **Nozzle:** Nozzle is the key component in spraying process. It is added in rover to spread the fluid onto the crops. Primarily, the atomized fluid flow can be obtained by nozzle.

Nozzle Type- Divergent
Nozzle Outlet- Conical spray distribution
Nozzle Material- Plastic

i.) **Nozzle Bar:** Nozzle bars are the metallic square rod that holds the nozzles. Nozzle bar can be adjusted in horizontal or vertical direction, and each of two bar holds two nozzle.

Number of Bars- 2

j.) **Remote Control:** It is basically the simple control device which is used to make the on/off-control over electrical components like motor and pump.

Remote Control Type- Simple On/ Off Buttons

k.) **Steering:** This mechanism is another element of control system of machinery, and is operated by the working person in order to give the directions to vehicle.

l.) **Pipe:** Pipes are used to transport the fluid from tank to pump and then to nozzles.

Material- Plastic
Internal Diameter- 0.007 m

6. DESIGN & OPERATION

6.1 3D Design of Vehicle

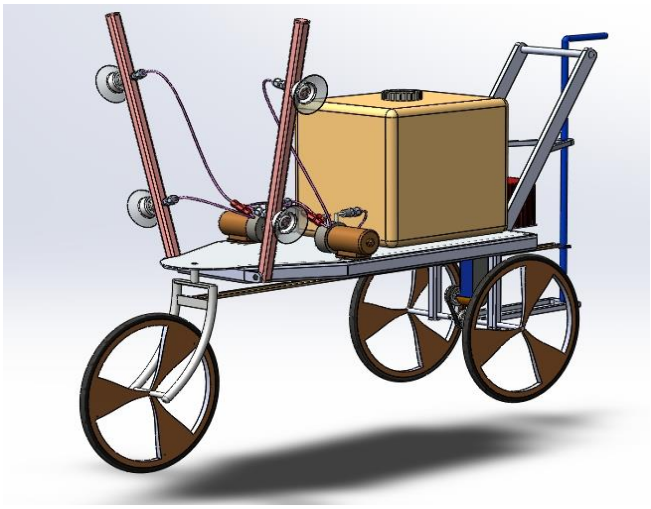

Fig -1: CAD Model

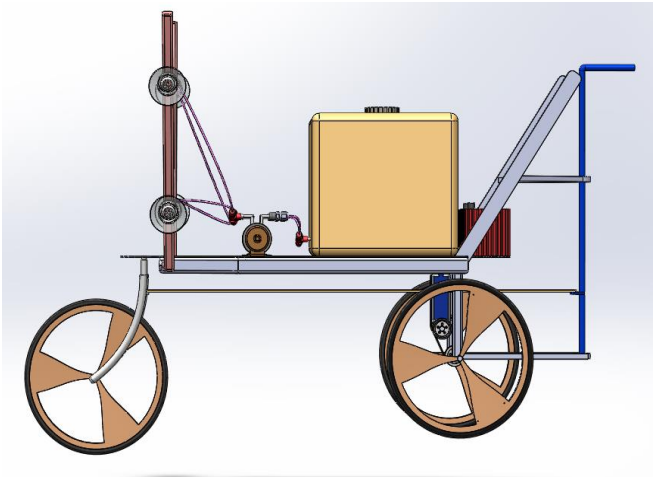

Fig -2: CAD Model

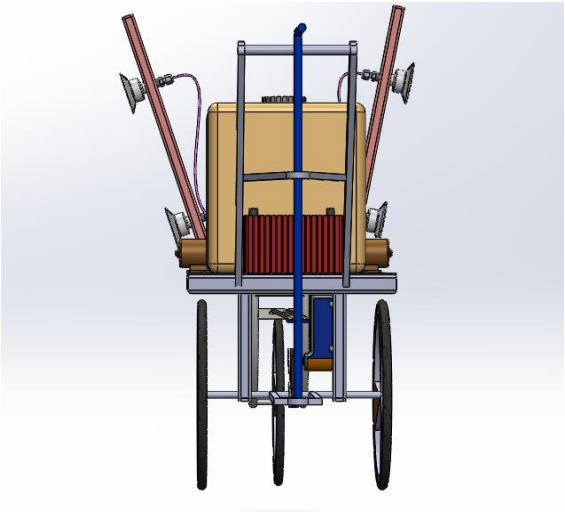

Fig -3: CAD Model

Fig -1, 2 & 3 display the 3D CAD model of the 3-wheel spraying rover. 3D-model was developed in SolidWorks.

6.2 Design Calculations

The design calculations are mainly divided into 2 part. Powertrain Calculations (6.2.1) and Fluid Mechanics Calculations (6.2.2). Powertrain calculations have a set of mathematical calculations of DC Servo Motor, Chain Drive, Shaft and Wheel. While, Fluid mechanics Calculations have a set of different component's designs like Pipes, Pump, and Nozzle system.

6.2.1 Powertrain Calculations:

a.) *Desired Maximum Velocity for Vehicle:*

- Given Parameters

Wheel Radius (Rw)= 0.195 m
Output Speed at Shaft (N)≅ 40 RPM
Angular Velocity of Vehicle= $\boldsymbol{\omega}$

- Desired Vehicle Velocity (V_{max})= Rw*($\boldsymbol{\omega}$)
  = Rw*($2\pi N/60$)
  = 0.195*(2π*40/60)
  ∴ (V_{max})= 0.815 m/s

The reason behind taking desired velocity of 0.815 m/s is because, the average person takes a footstep of roughly around 0.8 meter at the time of normal walking speed.

b.) *Tractive Force required to move the Vehicle:*

- Given Vehicle Parameters

  Mass of the Vehicle (m)= 25 kg
  Gravitational Force (g)= 9.81 m/s²
  Total Weight of Vehicle (Wv)= m*g= 245.250 N
  Wheel Radius (Rw)= 0.195 m

- Parameters affecting Required Torque

  Coefficient of Rolling Resistance= Crr
  Grade or Inclination Angle= Ø
  Maximum Vehicle Velocity= V_{max}
  Maximum Required Time to obtain maximum vehicle velocity= t_{max}

∴ Tractive Force (Ft)= {Rolling-Resistance (RR) + Grade-Resistance (GR) + Acceleration-Force (AF)}

- Rolling-Resistance (RR)= (Wv)*Crr
  =245.250*0.010
  (RR)= 2.452 N

(Crr has different values according to Contact Surface. But, here in this case we consider the Good Concrete as Contact Surface. So, Crr for Good Concrete surface is '0.010' selected from Standard Surface Friction Coefficient Table)

- Grade-Resistance (GR)= (Wv)*sin(Ø)
  =245.25*sin(0^0)
  = 245.25*0
  (GR)= 0 N

(Ø is the grade or inclination angle which means, the angle the vehicle will be expected to displace from its linear 0^0 angle. But, here in this case we used to drive the rover in plane angle. So, Ø would be 0^0. ∴ sin(Ø)= sin(0^0)= 0.)

- Acceleration-Force (AF)= (Wv)*Vmax/ (g*t_{max})
  =245.250*0.815/(9.81*1.0)
  (AF)= 20.375 N

(t_{max} simply going to be '1.0 Second' because the maximum vehicle velocity (V_{max}) is constant with 0.815 m/s value.)

∴ (Ft)= (RR) + (GR) + (AF) = (2.452) + (0) + (20.375)

∴ (Ft)= 22.827 N

c.) *Required Torque for Vehicle Displacement:*

- Given Parameters for Required Torque

  Wheel Radius (Rw)= 0.195 m
  Tractive Force (Ft)= 22.827 N
  Resistance Factor (R_f)= 1.10

- Required Torque (Treq)= (Rw*Ft*R_f)
  = (0.195*22.827*1.10)
  ∴ (Treq)= 4.890 Nm

(R_f is basically the frictional losses between bearings, axles, etc. & typical values ranges between 1.10 to 1.15)

d.) *Sprocket Size Ratio, Output Speed & Torque for Chain Drive:*

- Given Chain Drive Parameters

  Number of Tooth on both Sprockets (Ti/ To)= 14

Sprocket Size Ratio (X)= (Ti/ To)
= (14/ 14)
(X)= 1.0

∴ Sprocket Size Ratio (X) α Speed
∴ Sprocket Size Ratio (X) α 1/ Torque

- Sprocket Size Ratio= 1 α $\frac{\text{Speed}}{\text{Torque}}$
  ∴ Torque α Speed

That means, when the Sprocket Size Ratio is 1.0 then the Torque is directly proportional to Speed. So, Torque and Speed would be same at the input and output of the Chain Drive.

e.) *Torque for Motor:*

- Given Motor Parameters

  Motor Voltage (V)= 12V
  Motor Current On-Load (I)= 1.8A
  Motor Speed (N)= 40±42≅ 40.5 RPM

- Motor Power Output under Load,

  (Pm)= V*I
  (Pm)= 12*1.8 VA
  (Pm)= 21.6 W

Power and Torque relation equation
∴ Pm= (2πNTm/ 60)

- Motor Torque (Tm)= (60*Pm/ 2πN)
  = (60*21.6/ 2π*40.5)

  ∴ (Tm)= 5.095 Nm

f.) *Checking & Analyzing the Condition:*

- Given Parameters used for Condition

  Required Torque (Treq)= 4.890 Nm
  Motor Torque (Tm)= 5.050 Nm

  ∴ Tm ≥ Treq This condition must be satisfy.

  ∴ 5.050 ≥ 4.890 Hence, Condition is satisfied.

∴ Motor Torque ≅ Required Torque for Vehicle Displacement

Ultimately, Vehicle Displacement would be possible. Design calculations of DC Motor, Chain Drive & Wheel meet the requirement of Desired Vehicle Velocity.

6.2.2 Fluid Mechanics Calculations:

a.) *Power & Volumetric Flow Rate for Pump:*

- Given Pump Parameters

  Pump Voltage (V)= 12V
  Pump Flow= 6 Litre per Minute
  Pressure (Pp)= 135 PSI= 9.3 Bar

- Pump Volumetric Flow Rate (Qp)= 6 litre/ min
  =(0.006/60)m³/s
  (Qp)= 0.0001 m³/s

b.) *Pipe Area for Nozzle:*

- Given Parameters

  Pipe Area (Ai)= [(π/4)*D²]= 3.846*10⁻⁵ m²
  Pump Volumetric Flow Rate/ Discharge(Qp)= (Qi)= 0.0001 m³/s

c.) *Inlet & Outlet Properties for Nozzle:*

- Given Inlet Parameters for Nozzle

  Inlet Nozzle Velocity= Vi
  Inlet Nozzle Discharge= Qi
  Inlet Nozzle Area= Ai

- Given Outlet Parameters for Nozzle

  Outlet Nozzle Velocity= Vo
  Outlet Nozzle Discharge= Qo
  Outlet Nozzle Area= Ao

According to Continuity Equation,

∴ ρAV= Constant

So, ∴ AiVi= AoVo

(Where, Density of Fluid remains same. So, ρ is cancelled out on both side in Continuity Equation)

AiVi= Qp= Qi (Pump Volumetric Flow Rate or Discharge)
AiVi= AoVo= 0.0001 m³/s

The (AoVo) term is Total Nozzle Discharge of all 4 Individual Nozzles.

$AoVo = (Ao_1Vo_1 + Ao_2Vo_2 + Ao_3Vo_3 + Ao_4Vo_4)$

And all 4 nozzle have same input and output properties. They all have same input flow rate and output flow rate as they all are Diverging and have a similar design.

$Ao_1Vo_1 = Ao_2Vo_2 = Ao_3Vo_3 = Ao_4Vo_4 \Rightarrow (AoVo)_{Individual}$

∴ $AoVo = 4*(AoVo)_{Individual}$
$0.0001 = 4*(AoVo)_{Individual}$
$(AoVo)_{Individual} = 0.0001/4$
$(AoVo)_{Individual} = 2.5*10^{-5}$ m³/s

∴ $(AoVo)_{Individual}$= 2.5*10-5 m³/s
Or
∴ $(AoVo)_{Individual}$ = 25 ml/s

Total Nozzle Discharge is,

∴ $(Qo)_{Total} = (AoVo) = 1*10^{-4}$ m³/s
Or
∴ $(Qo)_{Total}$ = 100 ml/s

Which means, the nozzle throws fluid at 25 ml/second. Hence, the Total Nozzle Discharge of the rover is 100 ml/second. Suppose the conventional sprayer discharge Q_1 is 25 ml/s. While proposed sprayer have 4 times discharge of pesticides/ fluid than conventional sprayer Q_2 which is 100 ml/s. So that, more crops could be covered during the spraying operation and simultaneously time can be saved. Ultimately, efficacy and efficiency both are more in this spraying rover.

6.3 Actual Design

The assembly or actual model was manufactured in the college workshop. The diverse mechanical operations were done like welding, cutting, grinding, drilling and painting. The wheels, pumps and battery were purchased from the stores. While, the steering mechanism, nozzle bar, power train and body frame of the vehicle were developed in the workshop.

Firstly model name was 'Manual Controlled Electric Driven Rover for Multiple Spraying Purpose'. Due to its lengthy name later on it was renamed as "3- Wheel Electric Vehicle for Multiple Spraying Purpose".

Fig -4: Actual Model

Fig -5: Actual Model

Fig -6: Actual Model

6.4 Operation Flowchart

Fig -7 of flowchart depicts the various stages to complete the operation by the proposed-designed vehicle. Firstly, the fluid (pesticides/disinfectants/water) is poured into the tank as per the requirement. In the next stage, nozzle-bars are positioned vertically or horizontally according to the size and shape of crop existed on farm site. Therefore position depends on the arrangement and how big/small the crop on the farm site. The next step is to modify the nozzle output flow-rate as per the farmer does require. After that, the rover is started by power on the motor and then turn on the pump to make sprinkling of fluid. The rover is driven with the help of steering. At the end, once the operation has been done the battery is recharged. Hence, rover can be ready to reuse for the next operation.

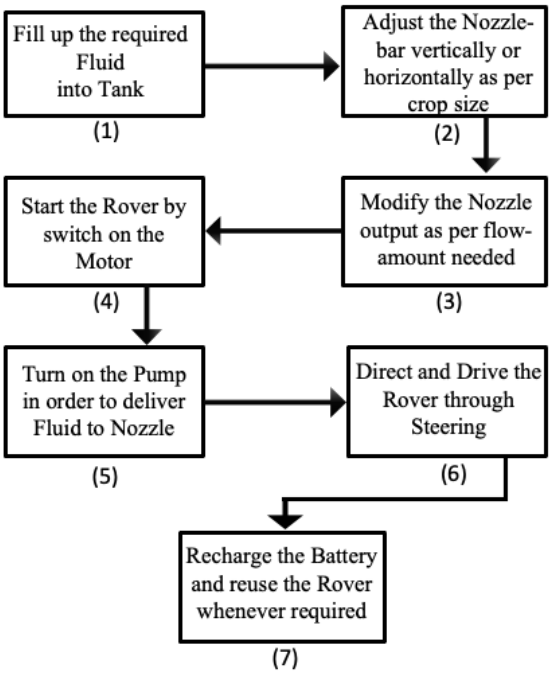

Fig -7: Operation Flowchart

7. COST ANALYSIS

Table -2 shows the cost analysis for the manufactured rover. The components are of average price and with good quality as compared to parts used in other spraying machines. Also, the development of chassis and steering is also manufactured with primary manufacturing cost. Our main goal was to manufacture a machine which is able to be developed at a low cost compared to others and provide the same to the industries/places where conventional machines are utilized. *(Nos. = Numbers of Quantity)*

Table -2: Cost Analysis Table

Sr. No.	Name of Components	Cost (in Indian Rupees)
1	Electric DC Motor	2500/-
2	Electric Pumps (2 Nos.)	1500/-
3	Tank (15 Liter)	400/-
4	Nozzles (4 Nos.)	175/-
5	Chassis (0.80*0.30*0.42 m)	1000/-
6	Chain Drive (2 chain sprocket, 1 roller chain)	500/-
7	Rechargeable Battery (12V 7Ah)	1650/-
8	Pipe (4 Nos.)	250/-
9	Nozzle Bars (2 Nos.)	300/-
10	Steering	400/-
11	Wheel (3 Nos.)	1200/-
12	Bearing (3 Nos.)	900/-
13	Remote Control	200/-
14	Other	250/-
Total		**11,225/- INR**

8. CONCLUSION

The development of the "3-Wheel Electric Vehicle for Multiple Spraying Purpose" is success-fully completed that uses different types of fluid like pesticides, disinfectants or water. Finally based on the described factors it can be concluded that proposed model tend to have less time required to perform the spraying task. As a consequence, efficiency would be going to high and labor charge will be lower as

compared to existing back- pack sprayers. Nozzle output and nozzle adjustments bring the advantage of effectiveness in working. It is found that this rover could be remain as welfare, economical and efficient aspect in both agriculture and health sectors. Thus the proposed vehicle or rover model offers more benefits against the conventional sprayers.

REFERENCES

[1] Shailesh Malonde, Shubham Kathwate, Pratik Kolhe, Roadney Jacob, Nishat Ingole, Rupesh D. Khorgade. "Design and Development of Multipurpose Pesticides Spraying Machine" Journal of Advanced Engineering and Global Technology ISSN No: 2309-4893 Vol-04, Issue-03, May 2016.

[2] Akhilesh K. Bhatkar, P.B. Khope, P.S. Chaudhari, "Development Of Pesticide Spraying Machine" International Journal of Research in Engineering and Technology ICESMART-2016 May-2016, eISSN: 2319-1163 pISSN: 2321-7308.

[3] Dhiraj N. Kumbhare, Vishal Singh, Prashik Waghmare, Altaf Ansari, Vikas Tiwari, Prof. R.D. Gorle. "Fabrication of Automatic Pesticides Spraying Machine" International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056 Volume: 03 Issue: 04, April 2016.

[4] Faijubhai Malek, Dipam Patel, Yash Padia, Mit Kundariya, Varun Jarsania. "Mechanically Operated Cart for Pesticide Sprayer for Agriculture" International Journal of Innovative Research in Science, Engineering and Technology. An ISO 3297: 2007 Certified Organization Vol-05, Issue-05, May 2016.

[5] Saurabh Chauhan. "Motor Torque Calculations For Electric Vehicle" International Journal Scientific & Technology Research. Vol-04, Issue-08, August 2015, ISSN 2277-8616.

[6] https://en.wikipedia.org/wiki/Agriculture_in_India.