Electrically Run Agriculture Sprayer Vehicle

Steffin Antony Bristow, [1] Vennapusa Nageshwar Reddy, Vithal Channoor, [1] Manideep D.J ,[2] Suresha .S

[1]UG scholars, School of Mechanical Engineering, REVA University, Bengaluru, India
[2]Assistant Professor, School of Mechanical Engineering, REVA University, Bengaluru, India

ABSTRACT: The main work done is in manufacturing an agricultural sprayer vehicle that is to be electrically driven. The vehicle will use a battery from which it receives the required power. The power from the battery will be used to run a set of two motors fitted at the rear wheel of the vehicle. As the motor runs, the wheels attached to it also rotate thereby rotating the crank attached to it. There is also a connecting rod used whose one end is attached to the crank and the other end is connected to the pump of the tank. The main function of the crank and connecting rod arrangement is to convert rotary motion from the wheels into reciprocating motion of the pump.

KEYWORDS: Reciprocating, rotary, Sliding-crank mechanism, Multi-sprayer, Delay-circuit, knapsack, Drone.

1. INTRODUCTION

Farming is the backbone of Indian economy. In this agriculture sector there is a lot of field work, such as weeding, reaping, sowing etc. Apart from these operations, spraying is also an important operation to be performed by the farmer to protect the cultivated crops from insects, pests, funguses and diseases for which various insecticides, pesticides, fungicides and nutrients are sprayed on crops for protection.

A pesticide sprayer has to be portable and with an increased tank capacity as well as should result in cost reduction, labour and spraying time. In order to reduce these problems, there are number of sprayer introduced in the market but these devices do not meet the above problems or demands of the farmers. The conventional sprayer having the difficulties such as it needs lot of effort to push the liver up and down in order to create the pressure to spray. Another difficulty of petrol sprayer is to need to purchase the fuel which increases the running cost of the sprayer. In order to overcome these difficulties. We have proposed a wheel driven sprayer, it is a portable device and no need of any fuel to operate, which is easy to move and sprays the pesticide by moving the wheel. The mechanism involved in this sprayer is reciprocating pump, and nozzles which were connected at the front end of the spraying equipment.

Generally farmer uses traditional way that is spray carried on backpack and spraying crop this becomes time consuming, costly and human fatigue is major concern. Present day in agriculture the sprayers play an important role in spraying pesticide. The current idea on sprayer in our project is to utilize effectively for reducing time of spraying, human efforts and cost of spraying. The conventional sprayer having some difficulties such as it needs lot of effort to push the lever up and down in order to create the pressure to spray. Another difficulty of petrol sprayer is to need to purchase the fuel which increases the running cost of the sprayer; it produces more vibrations and noise that irritates the farmer and he refuse to do such work repeatedly. In order to overcome these difficulties, we have proposed a wheel driven sprayer, it is a portable device and no need of any fuel to operate, which is easy to move and sprays the pesticide by moving the wheel.

According to idea in our project we are making a small agricultural reciprocating multi sprayer which is mechanically operated by a slider crank mechanism.

One vertical arm is attached at in front of cycle and one horizontal arm at top of the vertical arm. Nozzles are fitted to this arm so that it can spray pesticide both the sides. As more no of nozzle are there hence spraying is done rapidly and time and money is saved.

2. LITERATURE SURVEY

2.1 Highlights of the Previous Sprayer Vehicle

- The previously constructed agricultural sprayer vehicle consisted of only a single nozzle sprayer.
- The entire vehicle was balanced only on three wheels.
- The vehicle was to be moved manually by pushing it.
- The discharge pressure as well as the tank capacity was low.
- The ground clearance was very less.

2.2 Components Used in the Previous Agriculture Sprayer Vehicle

Base Frame or Chassis

The base of frame of chassis is a mild steel fabricated structure that holds the entire assembly of the sprayers. The rear sides' caries the rear wheel shaft that carries the rear wheel, the front wheels steering carries the front wheels bracket which provides the necessary turning effects.

Drive Assembly

The drive assembly consist of the driver pinion on rear shafts, and the spur gear on the crank. Thus when vehicle moves in forward directions the wheel will rotate the rear wheels shaft and hence the driver gear drive the driven gear and there by the intermediate shafts and the pitman arms which reciprocates the piston of sprayer.

Pump System

The pump systems comprises of sprayer mechanisms of 3 litre capacity integrated with an inbuilt pump and sprayer.

Air storage and pesticide storage

Compressed air is stored in the air chamber of storage tanks and the pesticides are stored in the liquid chamber, the sprayers connected to the tanks sprays this liquid pesticides using the compressed air.

2.3 How the Previous Agriculture Sprayer Vehicleworked (working Principle)

- When the equipment is push forward by using handles, front wheel rotates and the gear is mounted at the axle of wheel is start to rotate and its rotation is then transferred to the pinion through the chain drive.
- The rotary motion of the pinion is converted into the reciprocating motion by the single slider crank mechanism, due to this arrangement the connecting rod moves upward and downward which then reciprocate the piston of single acting reciprocating pump mounted at the top of storage tank.
- During the upward motion of the connecting rod the pesticide is drawn into the pump and during the downward motion of connecting rod the pesticide is forced to the delivery valve, the delivery is connected to the pipe carrying the number of nozzles.
- Due to the motion of wheels, the chain drive mechanism operates to reciprocate the piston inside the pump cylinder. But, this results in building up of pressure which seizes the movement of wheels. Thus, a clutch mechanism is provided to disengage the transmission from the crank to the piston.

2.4 Applications

- For the insecticides application to control insect pests on crops and in stores, houses, kitchen, poultry farms, barns, etc.
- For the fungicides and bactericides application to control the plant diseases.
- For the herbicides application, to kill the weeds.
- For the harmony sprays application to increase the fruit set or to prevent the premature dropping of fruits.
- For the application of plant nutrients as foliar spray.
- For applying the powdery formulation of poisonous chemicals on the crops and for any other purposes.
- To eliminate the difficulties faced during the use of backpack sprayers such as worker fatigue.
- To eliminate the need for manually pumping the sprayer to create pressure.
- To make the overall usage of a backpack sprayer easier by mounting it on a vehicle where the rotary motion of the wheels of the vehicle is used to

generated required pressure in the pump to spray the pesticides.

2.5 Demerits of the Previous Sprayer Vehicle

- The vehicle had to be pushed manually due to which it lead to fatigue of the worker.
- Since the vehicle was manually run it was time consuming.
- The previous vehicle used a single nozzle to spray the pesticides therefore area covered was very small.
- Since the vehicle had only 3 wheels therefore there was comparatively lesser balance.

2.6 Changes or Modification that we intend to make to the Existing Vehicle (Objectives)

- To increase the tank capacity from 5 liters to 8 liters.
- To use lighter and harder materials in the construction of vehicle body.
- To reduce the overall diameters of gear and pinion to make the vehicle more contact.
- To increase the volume of pesticides discharged from the pump.
- To decrease the nozzle diameter to increase the pressure of discharge to increase coverage.
- To make use of 4 wheels for better balance of the vehicle.
- To run the vehicle electrically by including a battery and a motor.
- To make use of a delay circuit within the vehicle in order to decide on the distance up to which the vehicle has to move.

3. METHODOLOGY

3.1 Construction

Sprockets:

The name 'sprocket' applies generally to any wheel upon which radial projections engage a chain passing over it. It is distinguished from a gear in that sprockets are never meshed together directly, and differs from a pulley in that sprockets have teeth and pulleys are smooth. We use freewheel and chain wheel for chain and sprocket arrangement.

Chain:

The chain is made of steel which is used to transmit power from gear sprocket to pinion sprocket, and it has a no sleep.

Crank:

The function of crank is to transfer motion from prime mover to the connecting rod for further operation. Here the circular disc having eccentricity at which rotary motion of crank is converted into reciprocating/linear motion of connecting rod.

Connecting rod:

The main function of connecting rod is to convert rotary motion into reciprocating/linear motion. Here connecting rod converts rotary motion of crank to reciprocating motion of pump and extension rod.

Pump:

It consists of piston and cylinder arrangement, it has a lever to operate the motion of piston in reciprocating direction. The pump generates the pressure of 2 bar and discharge of 2 lpm.

Nozzle:

is a device which converts the pressure energy of fluid into kinetic energy, spray nozzle is a precision device that facilitates dispersion of liquid into a spray. Nozzle is used for purpose to distribute a liquid over an area.

Wheel:

Wheel is used to carry the whole assembly and move machine from one place to another by rotary motion of it. A bicycle wheel is a wheel, most commonly a wire wheel, designed for a bicycle. Bicycle wheel is designed to fit into the frame and fork via drop outs, and hold bicycle tire. A typical modern wheel has a metal hub, wire tension spokes and a metal or carbon fiber rim which holds a pneumatic rubber tire. We use a tubeless tire wheel. The wheel used in our vehicle has a diameter of 12 inches.

Frame:

The main function of frame is to carry whole assembly on it so it has to be strong enough to hold it. The frame is made of square pipe and it is formed

out of mild steel. The frame will have provisions for four wheels as well as provisions for two separate motors for each of the two rear wheels.

Tank:

We want our tank to carry as much fluid as it can be along with its self weight as less as possible. We have taken a tank which is almost 16 liter capacity. A material for tank used is plastic fiber. Plastic fiber is very low in weight as compared to other materials. It also has very low cost.

Battery:

In order to make the vehicle electrically driven, we make use of a battery, which is used to drive a motor that is attached to the rear wheels which in turn assists in the mobility of the entire vehicle. The battery used is a 12V dc battery.

Motor:

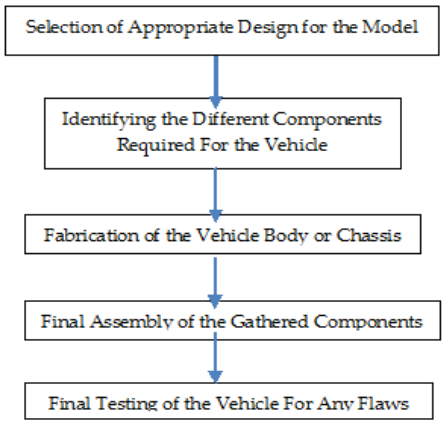
A 3 hp dc motor is connected to the rear wheels. This motor is run with the help of a 12V battery The movement of the vehicle is due to the rotation of motor by the battery.

3.2 Working Principle of Our Vehicle

The primary mechanisms that are involved in the working of the electrically run agriculture sprayer vehicle are give below in points

- Initially when the vehicle is switched on the battery provides the necessary power that is required to run the motor.
- 2 separate motors are attached to the two individual rear wheels. Therefore as the motors run, the two rear wheels also rotate.
- A crank and sprocket arrangement is connected to one of the rear wheels. The other end of the crank is attached to a connecting rod which in turn is connected to the pump of the pesticide tank.
- As the rear wheels rotate, the crank also rotates and the rotary motion of the crank is converted into reciprocating with the help of connecting rod.
- This reciprocating motion builds the necessary air pressure in the tank and thereby enables the high pressure discharge of pesticides through the nozzles.

4. Flowchart



5. ANALYSIS AND CALCULATIONS

5.1 Design:

For chain:

This is one of the most important parts of a SPV which gives the final push or motion to the wheels and make the vehicle move. It primarily consists of a chain and sprocket drive. A sprocket is a toothed wheel upon which a chain rides. Contrary to popular opinion, a sprocket is not a gear.

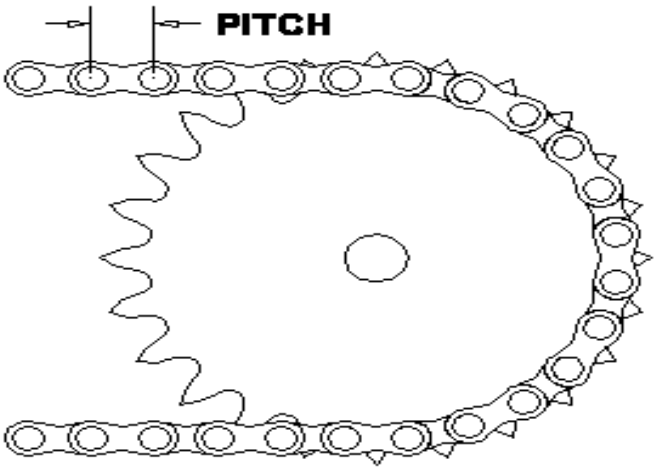


Fig 1: Profile of a chain

Chains have a surprising number of parts. The roller turns freely on the bushing, which is attached on each end to the inner plate. A pin passes through the bushing, and is attached at each end to the outer plate. Bicycle chains omit the bushing, instead using the circular ridge formed around the pin hole of the inner plate.

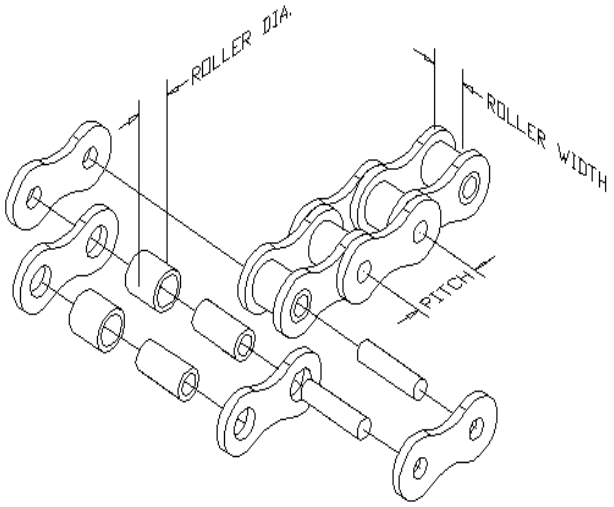


Fig. 2: Parts of a chain

Chain types are identified by number; i.e. a number 40 chain. The rightmost digit is 0 for chain of the standard dimensions; 1 for lightweight chain; and 5 for roller less bushing chain. The digits to the left indicate the pitch of the chain in eighths of an inch. For example, a number 40 chain would have a pitch of four-eighths of an inch, or 1/2", and would be of the standard dimensions in width, roller diameter, etc.

The roller diameter is "nearest binary fraction" (32nd of an inch) to 5/8ths of the pitch; pin diameter is half of roller diameter. The width of the chain, for "standard" (0 series) chain, is the nearest binary fraction to 5/8ths of the pitch; for narrow chains (1 series) width is 41% of the pitch. Sprocket thickness is approximately 85-90% of the roller width.

Sprocket

There are four types of sprocket;

- Type A: Plain Plate sprockets
- Type B: Hub on one side
- Type C: Hub on both sides
- Type D: Detachable hub

Sprockets should be as large as possible given the application. The larger a sprocket is, the less the working load for a given amount of transmitted power, allowing the use of a smaller-pitch chain. However, chain speeds should be kept less than 1200 feet per minute.

The dimensions of a sprocket can be calculated as follows, where P is the pitch of the chain, and N is the number of teeth on the sprocket;

Pitch Diameter = P ÷ sin (180° ÷ N)

Outside Diameter = P × (0.6 + cot (180° ÷ N))

Sprocket thickness = 0.93 × Roller Width - 0.006

Power to be transmitted, N = 0.25 HP **(**Losses are neglected)

= (1/4) * 746 Watts

= 0.1865 KW

Speed of driver sprocket, n_1 = 150 rpm

Speed of driven sprocket, n_2 = 150 rpm

Distance b/w Sprockets, C = 560 mm

For Roller Simplex Chain No. 04C (from table (21.67/Pg 355)),

Pitch, p = 6.35 mm

Measuring load, w = 0.05 KN/m

Breaking load, F_u = 3.4 KN

Transmission Ratio, i = (n_1/n_2) = (150/150) = 1

Taking No. of teeth on driver sprocket, Z_1 = 36

No. of teeth on driven sprocket, $Z_2 = i*Z_1$

= 36

Pitch diameter of driver sprocket, $d_1 = p \div \sin(180/Z_1)$

= 6.35 ÷ sin(180/36)

= 72.86 mm

Pitch diameter of driven sprocket, $d_2 = i*d_1$

= 72.86 mm

Velocity of chain, $V = (p*Z_1*n_1) \div (60*1000)$

= (6.35*36*150) ÷ (60*1000)

= .5715 m/s

From table (14.4/pg189),

load factor, K_l= 1.75

From table (21.61/pg351),

Service factor, K_s= 1.2

Power, $N = (F_\theta*V) \div (1000*K_l*K_s)$

=> .1865= (F_θ*.5715) ÷ (1000*1.75*1.2)

Required chain pull, F_θ= 665.72 N

Allowable pull, $F_a = F_u/n_o$

Here working factor, n_o= 5

$=>F_a = (3.4*10^3)/5$

= 680 N

No. of strands, $i_s = F_\theta/F_a$

= 665.72/680

= .979 < 1

It shows that a single strand (simplex) chain is sufficient to carry the required pull.

Length of chain in pitches,

$L_p = 2*C_p*\cos\alpha + (Z_1+Z_2)/2 + \alpha*(Z_1-Z_2)/180$

Where, $\alpha = \sin^{-1}((d_1-d_2)/(2*C))$

$= 0$

And, $C_p = C/p$

$\Rightarrow L_p = 2*560*\cos0^{\circ}/6.35 + (36+36)/2 + 0$

$= 212.38$ pitches

$= 214$ pitches (nearest even no.)

Length of chain, $L = p*L_p$

$= 6.35*214$

$= 1358.9$ mm

Substituting the value of L_p back in the above equation,

$\Rightarrow 214 = 2*C*\cos0^{\circ}/6.35 + (36+36)/2 + 0$

Correct centre distance, C= 565.15 mm

Check for actual factor of safety

Chain pull, $F_\theta = 1000*N/V$

$= 1000*.1865/.5715$

$= 326.33$ N

Centrifugal tension, $F_{cs} = w*V^2/g$

$= .05*1000*.5715^2/9.8066$

$= 1.665$ N

From table (21.58/pg351), for horizontal drive,

Coefficient of sag, $K_{sg} = 6$

Tension due to chain sag, $F_s = K_{sg}*w*C$

$F_s = 6*.05*1000*560/1000$

$= 168$ N

Actual FOS, $n_o = F_u/(F_\theta+F_{cs}+F_s)$

$\Rightarrow n_o = 3.4*1000/(326.33+1.665+168)$

$= 6.85 > 5$

Hence, selection of chain is safe.

Selection of electric motor

A) DC Motor Speed (N) = 100 RPM

B) Voltage (V) = 12 Volt

C) WATTS = 18 WATT

Electrical (electric) power equation

A) Power (P) = I × V Where,

V = 12 V

P = 18 W Then,

I=18/12 =1.5

B) In hp = 0.02414hp

5.2 Findings and Analysis

After performing calculations using the available standard formulae for the required dimensions of frame, wheel, pump, chain and sprocket we implement the results obtained from the above mentioned calculations in the fabrication of frame, wheel, pump, chain and sprocket. The above two images shown are the front and side view of the completely fabricated model of our project.

As seen in the above two images the completely fabricated portion of our model consists of a total of four wheels of diameter 12 inches which assist in giving better balance to our vehicle. Also as seen in the above images there are two sets of motors attached to each of the rear wheels which will be driven by a battery.

There is also a chain and sprocket arrangement attached to one of the rear wheels to which will be attached a crank and a connecting rod and the other end of the connecting rod will attached to the pump of the tank which is basically required to transfer the rotary motion from the wheel into reciprocating

motion of the piston in the pump to build the required pressure in the pump to spray the pesticides.

Fig 3: Electrically run Agriculture Sprayer Vehicle fabricate by our group

6. CONCLUSION

- The various design parameters of the vehicle are analysed and calculated with the help of available standard formulae.
- The specifications of motor and battery are decided based on the size and other dimensions of the vehicle.
- The vehicle is made to run on battery and motor rather than manually pushing the vehicle.
- It is desired to limit the distance of the vehicle by making use of a delay circuit.

FUTURE SCOPE

- The project has a greater future scope as it is not manually operated and does not lead to the workers fatigue.
- The vehicle can be use in areas that require large coverage of land with pesticides due to the use of a multi nozzle sprayer and also due to high pressure generated.
- Due to the use of delay circuit to limit distance, the worker need not run behind the vehicle to switch it off.
- The balance of the entire vehicle is improved by increasing the number of wheels.

REFERENCES

[1] R. Joshua, V. Vasu and P. Vincent "Solar Sprayer - An Agriculture Implement""International Journal of Sustainable Agriculture 2.

[2] R. D. Fox, R. C. Derksen, "Visual and image system measurement of spray deposits using water–sensitive paper" Applied Engineering in Agriculture American Society of Agricultural Engineers .

[3] M. A. Miller, B. L. Steward, M. L. Westphalen "Effects of multimode four–wheels steering on sprayer machine performance", American Society of Agricultural Engineers .

[4] A. Taiwo K. Oje, "Development and testing of a swirl chamber nozzle", Journal of Agricultural Engineering and Technology (JAET).

[5] Shivraja Kumar.A and Parameswaramurthy.D "Development of wheel-driven sprayer", International Journal of engineering research, Vol.2.

[6] Laukik P. Raut, Smit B. Jaiswal, Nitin Y. Mohite, "Design, development and fabrication of agricultural pesticides sprayer", International Journal of applied research and studies (iJARS)