International Journal of Scientific Research in Engineering and Management (IJSREM)
Volume: 04 Issue: 06 | June -2020 ISSN: 2582-3930

Design and fabrication of multi nozzle pesticide spraying machine

Zuber S. Rangrej[1], Sachin N. Patil[2], Yatish H. Patel[3], Nimesh V. Rana[4], Prince D. Patel[5]

Guide: Prof. Milan A. Senjaliya & above listed from Department of Mechanical Engineering Shree Swami Atmanand Saraswati Institute *of* Technology, Surat, Gujarat, India.

Abstract - The main aim of our project is design and fabrication of mechanical pest sprayer, we have designed a model running without any fuel (except the second working method of motor for special purpose) and also easy to operate for a user. In this model we find that we have simply used a sprocket mounted on front shaft which will actuate piston inside cylinder with the help of crank and slider mechanism. Also the assembly consist of 3 wheel out of which one are mounted on front shaft and other two are mounted as guide wheel at rear end. A sprocket is mounted on front side exactly at the end of the shaft. By pushing the trolley, sprocket rotate in its direction so it actuates the piston inside the cylinder and non-return valves are take their position, due to this compression takes place inside the tank. So it leads to spray pesticides (or) water inside the tank. By our project, spraying is done using mechanism. The effective control of spray is done by valve mechanism. The position of nozzle is changed with rotation of nozzle bar. This project is requiring less amount of human effort for spraying.

***Key Words*:** Pesticide, Sprayer, Mechanism, Nozzle, Reciprocating pump, Machine, Sprocket

1.INTRODUCTION

1.1 Origin of The Work

India is an agriculture dependent country in which 60-70% of population is dependent on farming. India is rank 2nd worldwide in farm output. Agricultural accounted for 15.4% of GDP in 2017. So, for increase crop production and reduce human effort, farmer use different type of agricultural machinery, different pesticide from the ancient time. Now a day they use various pump for spraying pesticide like hand operated pump, battery operated pump.

Mostly in India we used old method and equipment for the agricultural. For agricultural the pesticide and water is mostly required after some interval of time to remove the insect from the agriculture land. In old equipment only one work has been performed at a time due to which the time as well as effort required is more. The agricultural field being small, automation in such places is a difficult task also the economic condition of majority of Indian farmer is not well to do. Therefore, the manually operated sprayer found wide application in such condition.

1.2 Problem Statement

Now a day one of the difficult task in farming is spraying the pesticides on the crops and fruits. But the use of backpack type pump causes the reason of back pain and shoulder pain of the farmers. Also this process is time consuming and cannot be used in large sized farms. In big farms the farmers use tractor to spray the pesticides which cause the wastage of large quantity of pesticides. To reduce such wastage and to reduce the time of spraying our machine will be very useful in the farming.

Our project has two different source of liquid spray technique one by crank and slider mechanism (reciprocating pump) another is by Electric motor both have their individual advantages. The flow of liquid is supply to valve mechanism thought which volume of liquid and side of spray (i.e. left/right) is control. Nozzle are place at nozzle bar. Nozzle bar is free to rotate in 90° of motion.

1.3 Research Gap

For seeking different ways to improve the equipment quality while reducing the direct overhead costs (labour) and capital, the project has been made. Thus, a significant opportunity rests with understanding the impact of a pesticide sprayer seed sowing equipment in an agriculture field. A pesticide sprayer seed sowing equipment has to be portable and with an increased tank capacity as well as should result in cost reduction, labour, seed sowing and spraying time. In order to reduce these problems, there are number of sprayer and seed sowing equipment introduced in the market but these devices do not meet the above problems or demands of the farmers. The conventional sprayer and seed sowing equipment 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 and seed sowing equipment. In order to overcome these difficulties, we have proposed a wheel driven sprayer and seed sowing equipment, 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. And for seed sowing equipment the mechanism is chain and sprocket.

1.4 Aim and Objective

Our aim is to provide an effective mechanism which is able to fulfill the requirement of farmers. For agriculture based country like India control of pest is an important factor. This process of spraying pesticides using spraying equipment plays an important role.

Our machine is also useful for Gardner to spray different liquid. Our aim is to reduce the complicity and the effort required during the process of spraying, this is done by the available flexibility of our product like control of spraying liquid, alternative options for left or right side spray, two drive mechanism one as motor and another as hydraulic cylinder.

Our objective is as follow:

- The suggested model can remove the problems of back pain, since there is no need to carry the tank (pesticides tank) on the back and solder.
- Work reliability under different working conditions.
- Machine can be used in small as well as in large crop area.
- To increase the efficiency of spraying with
- effective control of spray.
- To decrease the working cost by using new mechanism.
- To decrease labour cost, as to provide single man operations system
- To increase the productivity of the crops.
- To save the time of the farmers as it provides rapid spray.

2. WORKING PRINCIPLE

2.1 WORKING PRINCIPLE (Manual operated pump)

1. Motion transmission by chain and sprocket arrangement.
2. Sliders crank mechanism.
3. Rotary motion converted into reciprocating motion.

2.2 WORKING PRINCIPLE (Battery operated pump)

1. The pump is operated by rechargeable battery.
2. A pressure measurement device is attached on the head of pump, which control the flow.
3. Pump is turn on by switch, not required any movement of machine.

2.3 Construction

Manually operated spray has simple structure it consists of 3 wheels, piston pump, bearings, nozzle, shafts, trolley, freewheel, handle chain drive, etc. There trolley is likely structure containing 3 wheels one at front and 2 at backside at rear. The rear wheels are connected by shaft. Bearings are provided at both sides for smooth motion. The front wheel is mounted at middle of the trolley. Freewheel is mounted on shaft connected to rear wheels. The freewheel is connected to crank shaft by chain drive. The crank shaft is then connected to piston pump with connecting rod. The piston pump is placed middle of frame which has reciprocating movement. The nozzle is mounted on angle, which mounted on frame. Nozzle having flexible pipe which is move or turn any direction. We can also adjust the height of the flexible pipe. We use 4 nozzles in our sprayer. The whole assembly is connected to handle.

[fig no. 1 Actual model of machine]

2.4 Working

The force applied by the person gives the motion to the machine. As the machine moves forward the front wheel will rotate and this rotating motion of the wheel is transmitted to the sprocket which is connected to the disc with the same shaft supported by the bearings. The gear ratio will give the exact rotation of the disc and required rotation. The rotational motion of the disc is converted into reciprocating motion of the pump by means of connecting rode. The reciprocating pump will flow the pesticides due to this motion and the pesticides will come out from the nozzles which are adjustable and flow regulated. Also the motor operated pump can be replaced at a place of reciprocating pump by shifting the nozzles pipe connection and disconnecting the reciprocating pump and disc by removing the connecting rode.

2.5 Description of parts of machine

1) Knapsack sprayer

A sprayer consisting of a handheld nozzle supplied from a pressurized reservoir that is carried on the back like a knapsack.

[fig no. 2 Knapsack Sprayer]

2) Sprocket

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. Big sprocket teeth – 25 Small sprocket teeth – 18

[fig no.3 Sprocket]

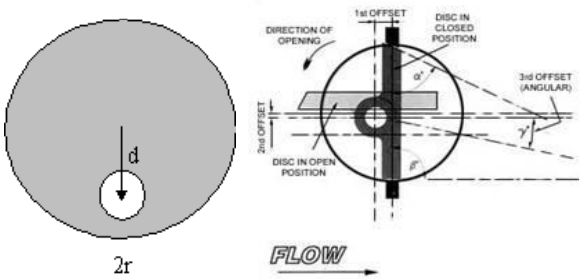
3) Eccentric disc

According to the stroke length of the piston the eccentric hole is drilled, from the centre point of the disc.

Diameter and Thickness of the disk: 16.5cm & 0.2cm

The eccentric hole is drilled 4cm from centre of the disk.

The total stroke length is 8cm.



[fig no. 4 Eccentric disc]

4) Wheel (fixed & universal)

There are two wheels are used fixed wheel and universal wheel. Both wheels are fixed. Front wheel is connected with the sprocket.

5) Nozzle

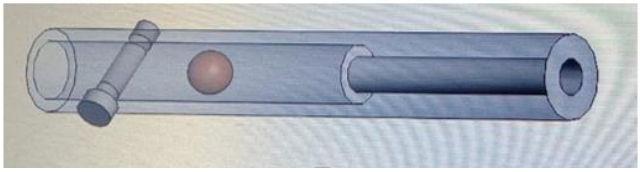
It is a device which converts the pressure energy of fluid into kinetic energy; spray nozzle is a precision device that facilitates dispersion of liquid into a spray. Nozzle is used for purpose to distribute a liquid over an area.

There are different types of disk in the nozzle which are fit in the nozzle. All the type of disk spray different because of the no. of hole in the disk like. Long distance spray, medium range spray, fog spray etc.

[fig no. 5 Nozzle]

6) Non return valve

Non return valve is use to prevent the pesticide to return in the tank. In non-return valve once pesticide pass from the pipe during suction stroke then valve get close during deliver stroke. So, the pesticide cannot return the tank.



[fig no. 6 Non return valve]

7) Pump

These types of pump operate by using a reciprocating piston. The liquid enters a pumping chamber via an inlet valve and is pushed out via an outlet valve by the action of the piston. There are total four non return valve are provided in Reciprocating pump. This type of pump is self-priming as it can draw liquid from a level below the suction flange even if the suction pipe is not evacuated. The pump delivers reliable discharge flows and is often used for metering duties delivering accurate quantities of fluid. The reciprocating pump is not tolerant to solid particles and delivers a highly pulsed flow. If a smooth flow is required, then the discharge flow

system has to include additional features such as accumulators to provide even flows.

[fig no. 7 pump]

8) Crank and Slider mechanism

In crank and Slider mechanism explained in crank is connected with slotted connecting rod. One end of connecting rod is connected with crank and the other end of rod is connected with the piston rod of pump. Centre of this rod is fixed with the frame of trolley and the rod is oscillating on this point. The crank slotted mechanism. This mechanism converts rotary motion into reciprocating motion. So this mechanism converts sprockets rotary motion into reciprocating motion of piston of pump.

9) Motor

The main function of the electronic pump is to flow the pesticide from tank to the nozzle. The pump is operated by the battery which is placed beside the pump. The pump creates the required pressure to flow the pesticide to flow the pesticide and can maintain the same pressure. The pump will stop itself when the required pressure is achieved.

[fig no. 8 Motor]

10) Valve mechanism

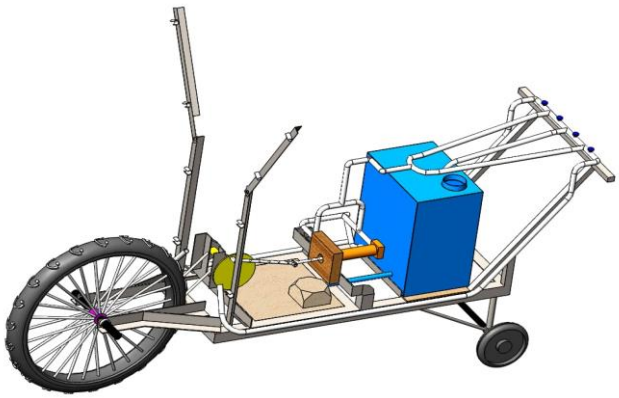
A valve mechanism is placed on handle of the vehicle, this valve mechanism is consisting two nozzle flow return valve and two T joint. The assembly is able to control the flow of liquid without any loss of liquid. This will helpful when required spray range is changed. Also this mechanism is able to close the sides of spray i.e. left or right side.

[fig no. 9 Valve mechanism]

3. PRODUCT DEVELOPMENT

3.1 Designed of Machine (Fabrication work)

This graphical model is prepared in Solid Work design software.



[fig no. 10 Graphical model]

3.2 Product function

- Semi manual
- Less effort
- Effective spray
- No electricity

3.3 Product features

- Manual operated
- Light weight
- Easy control

3.4 Purpose & Use

Purpose;

- Anti-insect
- Pesticide spray
- Plant growth
- Pesticide utilized
- Time utilized

Use for;

Farmer, Gardener, Painter and for Sanitizer spay.

3.5 Advantages of Spraying machine

1. This is of compact in size and less maintenance is enough.
2. Easy to use and uniform spraying.
3. Does not require buying any specially designed pump.
4. Portable and ergonomic.
5. Can work efficiently during all seasons.
6. It reduces the fatigue of operator during the working condition.
7. It can cover large area of land during spray.
8. It can adjust the height of spray by using adjustable nozzle.
9. The cost of operation is less compare to electrically and solar operated pump.

3.6 Disadvantages of Spraying machine

1. In uneven area of land, it can difficult to operate.
2. In rainy days in muddy environment it is difficult to operate.
3. For different crops the working of this pump is difficult to work.
4. No steering mechanism hence problem is created during turning of vehicle.
5. Initial cost is high as compare.

3.7 Application

1. For the spraying application of pesticide to control insect on crops and in stores, houses, kitchen, poultry farms.
2. It is very useful in sanitizing process to sanitize the area like in case of COVID-19 pandemic situation.
3. Domestic purpose, Industrial & painting applications.
4. For applying the powdery formulation of poisonous chemicals on the crops.
5. In city and urban area, it can use for spraying water on lawn.

4. MATHEMATICAL MODELING

4.1 Analytical Calculation

I. Hydraulic cylinder

- Length of cylinder (l) = 7cm
- Diameter of cylinder = 3cm & r_1 = 1.5cm
- Diameter of cylinder = 1.5cm & r_2 = 0.75cm

II. Volume of 1st stroke (cylinder volume)

$v_1 = \pi r_1^2 l$ = 49.5 cm^3

III. Volume of 2nd stroke (cylinder volume – piston volume)

$v_2 = v_1 - v'$ & $v' = \pi r_2^2 l$ = 12.36 cm^3

= 49.5 – 12.36

= 37.13cm^3

IV. Total volume in one revolution of disc (i.e. two adjacent strokes)

$v = v_1 + v_2$

= 49.5+37.13

= 86.63 cm^3 (0.086 liter) …….. let take as a v_a

4.2 Experimental Calculation

Tank volume = $l * b * h$ = $35 * 24 * 40$cm

Experiment: 1

Height of water = 1.5cm

Revolution = 13

Distance travel = 9.2 meter

Time = 20 sec

Valve position = full open

Fog of spray = 80cm

h = 1.5cm hence volume of pesticide used (v)

$v = 35 * 24 * 1.5 = 1260$ cm per 13 rev

So for one revolution the volume $(v_1) = \frac{v}{rev} = \frac{1260}{13} = 96.92$ cm^3 …..Let take as v_x

Loss of the pesticide,

$= \frac{v_x - v_a}{v_a} = \frac{96.92-86.63}{86.63} * 100\%$

= 11.87%

This loss is due to friction, change in cross section, bending loss, calculation error and many other.

Here is the table of another experiments,

1) Table of manual operated pump

Ex no.	1	2	3	4	5	6
Volume of liquid in cm^3	1870	672	650	1092	672	460
Revolution of disc (N)	24	20	19	18	18	18
Distance travel (m)	20	15.93	15.40	13.55	13.30	10.10
Time (sec)	42	27	30	23	14.69	9
Return valve position	Close	Close	Half open	Close	Half open	Open
No of nozzle open	4	2	4	4	4	0
Loss in %= $\frac{\frac{v}{n}-v_a}{v_a} * 100$	10.05	22.42	21.01	29.97	13.80	18.30

In case of return valve half open & number of nozzle are two than use $v = 43.315 cm^3$

2) Table of battery operated pump

No.	1	2	3
Time (sec)	30	30	30
Volume of pesticide used in cm^3	1260	1050	1470
No of nozzle	4	4	2
Return valve position	Close	Half open	Close
Distance of spray in cm	130 cm	73 cm	150 cm

Capacity of pump (experimental) = 42 cm^3/sec.

5. CONCLUSION

Following conclusion were drawn from this study,

1. The first conclusion is that this machine will eliminate the problem of carrying the pump on shoulder.
2. The spraying process can be completed rapidly.
3. This machine has 4 nozzles so the pesticides can be sprayed on the crops sufficiently and speedily.
4. The tank can fill up to 25 liter of pesticides at once so it does not require again and again refilling.
5. The nozzles height is adjustable so it can be used for every height of crops.

And also from experiment we can conclude that,

Loss of the pesticide,

$$= \frac{v_x - v_a}{v_a} = \frac{96.92 - 86.63}{86.63} * 100\%$$

$$= 11.87\%$$

This loss is due to friction, change in cross section, bending loss and many other.

For more information click on YouTube link :- https://youtu.be/-dTa6N7uuXw

6. FUTURE SCOPE

1. By providing a solar plate on a vehicle we can generate the electricity to charge the battery of pesticides pump and that also roof to prevent the direct sunshine toward the farmer.
2. By providing the steering mechanism to the back wheels of the vehicle we can easily turn the direction of the vehicle.

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BIOGRAPHIES

Zuber S. Rangrej perusing his Bachelor of Engineering in Mechanical Engineering from, Shree Swami Atmanand Saraswati Institute of Technology Surat-395006, Gujarat, India.

Sachin N. Patil perusing his Bachelor of Engineering in Mechanical Engineering from, Shree Swami Atmanand Saraswati Institute of Technology Surat-395006, Gujarat, India.

Yatish H. Patel perusing his Bachelor of Engineering in Mechanical Engineering from, Shree Swami Atmanand Saraswati Institute of Technology Surat-395006, Gujarat, India.

Nimesh V. Rana perusing his Bachelor of Engineering in Mechanical Engineering from, Shree Swami Atmanand Saraswati Institute of Technology Surat-395006, Gujarat, India.

Prince D. Patel perusing his Bachelor of Engineering in Mechanical Engineering from, Shree Swami Atmanand Saraswati Institute of Technology Surat-395006, Gujarat, India.

Prof. Milan A. Senjaliya has completed his Master of engineering in Machine design from C.K. Pithawala College of Engineering and Technology, Surat and Bachelor degree in mechanical from Mahatma Gandhi institute of technical education and research center, navsari. He is an assistant professor in Department of Mechanical Engineering at Shree Swami Atmanand Saraswati Institute of Technology.