AUSTRALIAN JOURNAL OF BASIC AND APPLIED SCIENCES

ISSN:1991-8178 EISSN: 2309-8414
Journal home page: www.ajbasweb.com

Modeling And Development Of Pedal Operated Agricultural Sprayer

[1]T. Subbarayudu and [2]Dr.N.Venkatachalapathi

[1]*PG Student, Mechanical Engineering, AITS, Rajampet, AP,*
[2]*Professor & Head Department of Mechanical Engineering, AITS, Rajampet, AP*

Address For Correspondence:
Asiah Ali, Universiti Sains Islam Malaysia, Faculty of Leadership and Management, 71800 Negeri Sembilan.
Email: thommarapu.subbarayudu@gmail.com

ARTICLE INFO

Article history:
Received 18 June 2017
Accepted 28 July 2017
Available online 20 August 2017

Keywords:
Sprayer, Foot sprayer, speed ratio, pedal operated sprayer, crank mechanism, reciprocating pump, CATIA, agriculture

ABSTRACT

The main aim of this project is to minimize the human effort and to increase the speed ratio between pedal operation and reciprocation of the pump and discharge rate in the sector of manual sprayers. In this project the foot sprayer can be modeled, developed and fabricated. This sprayer is also invented to easy operation and transport from the one field to another field. It can be operated by both the legs at a time so that the applying load will be distributed equally to both the legs of the operator. This pedal operated sprayer is implemented by introducing the crank mechanism which converts rotary motion into linear motion. Then the frame and reciprocating pump will be designed by using design software CATIA (Computer Aided Three Dimensional Interactive Application). The different parts are piston, push rod, plunger, crank mechanism, pedal mechanism, suction pipe with strainer and delivery pipe with gun or lance. This project will help formers in the agriculture for the purpose of pesticides and insecticides spray to control field crops and orchards.

INTRODUCTION

In India about 73% of population is directly or indirectly depends upon the farming. Hence it is said that India is an agricultural based country. A sprayer is a mechanical device used to spray the liquid like herbicides, pesticides, fungicides and fertilizers to the crops in order to avoid any pest. Sprayer provides optimum utilization of pesticides or any liquid with minimum efforts. Dusters and sprayers are generally used for applying chemicals. Distinguish the simpler method of applying chemicals and dusters are best suited for portable machineries and this usually requires simple equipment. But these devices are less efficient than sprayers, because of the low retention of the dust. Chemicals are widely used for controlling disease, insects and weeds in the crops. They are able to save a crop from pest attack only when applied in time. They need to be applied on plants and soil in the form of spray, dust or mist. The chemicals are costly. Therefore, equipment for uniform and effective application is essential. Dusters and sprayers are generally used for applying chemicals. Dusting, the simpler method of applying chemical, is best suited to portable machinery and it usually requires simple equipment. But it is less efficient than spraying, because of the low retention of the dust. High volume spraying is usually effective and reliable but is expensive. Low volume spraying to some extent overcomes the failings of each of the above two methods while retaining the good points of both.

Spraying is employed for a variety of purposes such as application of:

i. Herbicides in order to reduce competition from weeds,
ii. Protective fungicides to minimize the effects of fungal diseases,
iii. Insecticides to control various kinds of insect's pests,
iv. Micro-nutrients such as manganese or boron,

To Cite This Article: T. Subbarayudu and Dr.N.Venkatachalapathi., Modeling And Development Of Pedal Operated Agricultural Sprayer. ***Aust. J. Basic & Appl. Sci.,*** *11(11): 122-131, 2017*

Australian Journal of Basic and Applied Sciences, 11(11) August 2017, Pages: 122-131

The main function of a sprayer is to break the liquid into droplets of effective size and distribute them uniformly over the surface or space to be protected. Another function is to regulate the amount of insecticide to avoid excessive application that might prove harmful or wasteful. A sprayer that delivers droplets large enough to wet the surface readily should be used for proper application. Extremely fine droplets of less than 100 micron size tend to be diverted by air currents and get wasted. Crops should, as far as possible, be treated in regular swaths. By use of a boom, uniform application can be obtained with constant output of the machine and uniform forward travel.

Manual operated sprayers:

- Foot sprayer
- Hand sprayer
- Stirrup pump sprayer
- Hand compression sprayer
- Rocker sprayer
- Knapsack sprayer

1.1 Foot Sprayer:

Fig. 1.1:

The foot sprayer is one of the ideal and versatile sprayers used for multipurpose spraying jobs. The principle of working is similar to the rocker sprayer. The sprayer consists of a pump operated by the foot lever, suction hose with strainer, delivery hose, spray lance fitted with shut off pistol valve, gooseneck bend and adjustable nozzles. The pump barrel is mounted on a steel frame, which provides it stability when placed on the ground. It has a provision of two strong springs, which retract the foot lever to its original position after each pumping stroke. The sprayer does not have inbuilt tank, therefore an additional storage device or container is required to store the spray liquid in which the strainer ( ) f suction hose remain submerged It has provision for the two discharge lines, which increases its versatility and field capacity. The plunger pump being a positive displacement pump, builds up a high pressure to throw spray liquid to larger distances with a suitable boom. The pump barrel, lance and the spray nozzle are made from brass alloy. For operation the inlet pipe is placed in the storage container and one person continuously operates the pump by foot lever. There is a provision for the operator to hold the sprayer at the top by V-type fixture. The other person directs the lance to the target. For spraying tall trees up to a height of to m, a high jet or bamboo lance can be used.

1.2 Hand sprayer:

Fig. 1.2:

The hand sprayer is a small capacity pneumatic sprayer. It consists of chromium plated brass tank having a capacity of 0.5 to 3 litters (one liter is more common) which is pressurized by a plunger pump. The air pump remains inside the tank. For operation, the spray nozzle is directed to the target after charging. It is fitted with mist spray nozzle with goose~~k bend. The pump assembly is made of brass and operated by one person.

1.3 Stirrup pump sprayer:

Fig. 1.3:

The stirrup pump sprayer commonly used for Mosquito control, is quite popular among the small farmers and vegetable growers due its simplicity, low cost and ease of operation. It is also called bucket sprayer, as the pump always remains submerged in a bucket containing the spray liquid. One person operates the pump by placing his foot on the foot stirrup and moves the pump shaft fitted with D type handle. The other person holds the spray lance and directs it towards the target. All the major parts are made of brass. Usually a flat fan spray nozzle is used with the sprayer. The sprayer is provided with 5m delivery pipe. The field capacity of the sprayer is 0.3 ha/day.

1.4 Hand compression sprayer:

Fig. 1.4:

Hand compression sprayers are either pressure retaining or non-pressure retaining type. The pressure retaining type has an advantage that air charged once may last for weeks, but requires sturdy tank and high pressure, therefore these are not in common use. Non-pressure retaining type is the most commonly used hand compression sprayer. Like other sprayers, it consists of an airtight metallic tank, air pump, lance fitted with trigger type or shut off valve, and gooseneck bend a pair of should be mounted straps and nozzle. It has to carry it on the back. All the parts are made from brass alloy and the tank is fabricated to withstand high pressure up to the order of 18 kglcm2. For operation, the tank is filled to three fourths of its capacity and pressurized by hand plunger pump, which remain inside the tank or from a compressor. The pressure inside the tank is usually maintained at 3-4 kglcm2. The operator mounts the sprayer on his back securing it by shoulder straps and operates the trigger valve, which enables the spray liquid to flow through lance and nozzle. The lance is directed towards the target. A single person can operate the sprayer. For maintaining proper atomization of the spray liquid, the tank requires frequent pressurization. The discharge and atomization decreases with decrease in pressure.

1.5 Rocker sprayer:

Fig. 1.5:

The rocker sprayer is a long lever high-pressure sprayer designed for I operation with one or two lances. The complete assembly is mounted on wooden board, which is held to the ground by the foot of the operator. The I sprayer consists of a single or double acting piston pump for developing high pressure, an air chamber, spray lance with shut off valve and strainer, 5 m suction line fitted with strainer and delivery line. The principal components are made from brass alloy. The lance is fitted with gooseneck bend and nozzle and the length of lance may vary from 60 to 90 cm. The pump is operated with long lever to and fro in a rocking motion which sucks the liquid from the inlet pipe submerged in the spray liquid. The other person holds the lance and directs the spray chemical to the target. If two lances are used, then it may require in all three persons for the spraying operation. With high jet spray gun or bamboo lance the spray chemical can be delivered to a height of up to 10m.

1.6 Knapsack sprayer:

Knapsack sprayer consists of a pump and a air chamber permanently installed in a 9 to 22.5 liters tank. The handle of the pump extending over the shoulder or under the arm of operator makes it possible to pump with one hand and spray with the other. Uniform pressure can be maintained by keeping the pump in continuous operation.

Literature Review:

The pesticides are used to protect the field crops as well as orchards. Pesticide as a substance which is used to prevent, destroy or controlling the insects and disease of field crops as well as orchards in agriculture. In an average year, especially during the summer, one or more types of sprayers will be used by the average home gardener. Of the many products available, it is important to select the most efficient and easiest type for particular need, whether it is for applying insecticides fungicides, weed killers, liquid fertilizers or wetting agents. For example, lawn sprayer is made especially for the application of liquid materials to the lawn area. They are metered to allow quick mixing and coarse spray, so it does not take as long to apply weed killers, insecticides, etc. Also, there is not as much chance of drift of the liquid into nearby flower and shrub beds. Efficiency and accuracy vary considerably, especially with the type that attaches to the garden hose. Sprayers that are used for weed killing or for applying any type of soil sterility should not be used for any other purpose. In fact, you will find it a good practice to set a sprayer aside just for the lawn area. Use a separate one for flowers and shrubs. It is a good practice to clean out your sprayer immediately after you have used it for any type of spraying. A little soapy water, swished around and through sprayer, then flushed out with warm water, does good job.

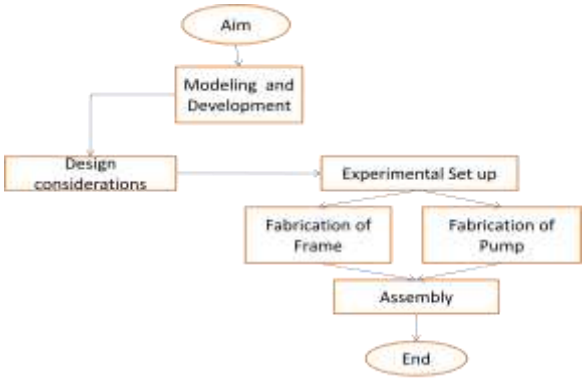
- Shivaraja Kumar Parameswaramurthys paper on design and development of wheel and pedal operated sprayer - It is a portable device and no need of any fuel to operate, which is easy to move and sprays the pesticide by moving the wheel and also peddling the equipment.
- Sandeep H. Poratkar, Dhanraj R. Raut,"Development of Multinozzle Pesticides Sprayer Pump"- This paper suggests a model of manually operated multi nozzle pesticides sprayer pump which will perform spraying at maximum rate in minimum time. Constant flow valves can be applied at nozzle to have uniform nozzle pressure**.**
- Varikuti Vasantha Rao Sharanakumar Mathapati Dr. Basavaraj Amarapur**, "**Multiple Power Supplied Fertilizer Sprayer"

Objectives:

1. To minimize the effort of the operator.
2. To increase the speed ratio between the operating system and plunger of the reciprocating pump.
3. To easy carry and transport in the agricultural field.
4. To easy maintenance and service.
5. It can be suitable for lancer and gun operates type of crops i.e. a Field crops and Orchards.
6. Spraying height and swath angle can be adjusted.
7. Sitting operation will arranged instead of standing operation

In this project foot sprayer will be develop to decrease human effort.

4.Methodology:



5. Modeling of Pump, Frame and then Assembly:

The frame, pump, gears, and remaining parts are modeled by using design software CATIA (Computer Aided Three Dimensional Interactive Application).

Reciprocating Pump:

Fig. 5.1:

A pump is a device that moves fluid (liquid or gases), or something slurries, by mechanical action. Any spray liquid must be atomized before leaves the spray nozzle. The pump facilitates the necessary pressure for this purpose.

Australian Journal of Basic and Applied Sciences, 11(11) August 2017, Pages: 122-131

5.1. Types of pumps:

Air Compression or Pneumatic pumps:

These pumps force air into an airtight tank containing
spray liquids thus moving the spray liquid under pressure through the nozzle for its atomization.

2) *Hydraulic or Positive Displacement Pump:*

These pumps take in a definite volume of spray liquid
and force it through the delivery system under pressure.
The pumps differ in pressure they produce.

Reciprocating pumps are the pumps in which the reciprocating motion done by the piston inside the cylinder.

That time the inlet and outlet valves are operates then the liquid or gasses are pumped. So the reciprocating pumps are hi pressure pumps. The working of reciprocating pump is shown in below figure.

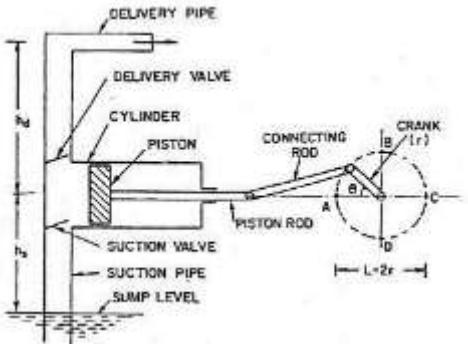


Fig. 5.2:

5.1.1. Base:

Base is used to support to fix the pump and remaining parts of the instrument. This base can be designed as shown in below figure.

Fig. 5.3:

Remaining parts (gears and pedals ton bearings, pressure gauge, and remaining parts

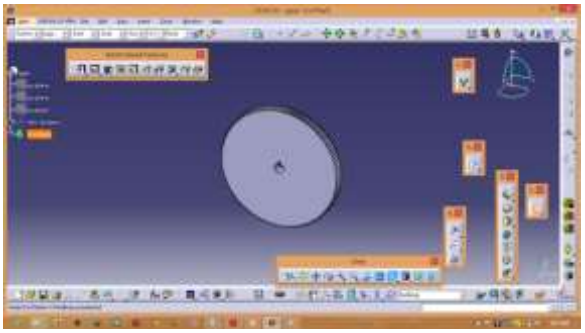


Fig. 5.4:

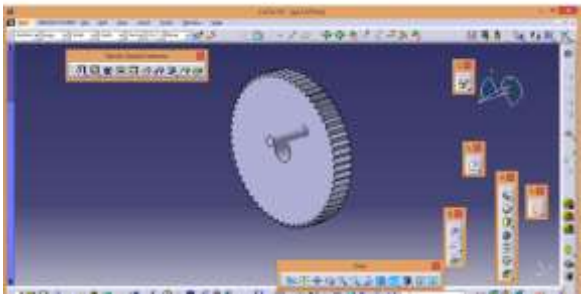


Fig. 5.4:

Fig. 5.6:

5.2 Fabrication of Frame:

One inch square pipe
1 inch M.S flat
1 inch circular pipe
1 inch angular designed for capable for carry about 100 kg loads, having a foot operated crank system to convert the rotary motion into linear motion, through gears drive transmission and then the seat is arranged for convenient to the operator for long time work. A support handles are provided to give proper comfort position to the operator.

5.3 Fabrication of Pump:

A cylindrical sleeve with 5cm diameter, in which a plunger assembly with seal arrangement will reciprocate to operate suction and delivery pressure. The input and outlet valves are provided for suction and delivery. A long rubber pipe is connected to a Gun to spray pesticide. A pressure chamber will provide to maintain the pressure. And a pressure gauge will provide at delivery side to indicate working pressure.

A separate storage tank is arranged with a capacity of 50-100 liters of liquidized pesticide. The suction pipe with a proper strainer is dipped into the storage tank. A drain plug is provided to drain the pesticide before storing the pump set. Level indicator also provide on the storage tank.

5.4 Assembly:

Then completion of the modeling and the design at last assembly was done. The assembly model shown in below

Fig. 5.7:

Australian Journal of Basic and Applied Sciences, 11(11) August 2017, Pages: 122-131

6. Working:

The developed model is shown in below. This model is help full for farmers to reduce spraying time in the field crops as well as in orchards.

Fig. 6.1:

A reciprocating pump essentially consists of a piston or plunger which moves to and fro in a closed fitting cylinder. A cylinder is connected to suction and deliver pipes, each of which is provided with non-return or one way valve called suction and delivery valve. A function of non-return or one way valve is to admit liquid in one direction only. Thus the suction valve allows the liquid only to enter the cylinder and delivery valve permits only its discharge from the cylinder. The piston or the plunger is connected to a crank by means of a connecting rod. The crank is connected to a gear wheel. In this the there are two gear are meshed one to each other. So the crank is weld to the small gear. The small gear is rotated at uniform speed by a driving paddle, then the piston or plunger moves to and fro in the cylinder. The small gear rotate from 0 to 180 degree the piston or plunger which is initially at its extreme left position moves to its extreme right position.

During the outward movement of the piston or plunger a partial vacuum is created in the cylinder, which enable the atmospheric pressure acting on the liquid surface in the well or sump below, to force the liquid up the suction pipe and fill the cylinder by forcing open the suction valve. Since during this operation of the pump, the liquid is sucked from below, it is known as suction stroke, thus at the end of the suction stroke, the piston or plunger is at its extreme right position, the gear is at 180 the cylinder is full of liquid, the suction valve is closed and the delivery valve is just at the point of opening. When the gear rotates from 180 to 360 degree of rotation the piston or plunger moves inwardly from its extreme right position towards left. The inward movement of the piston or plunger causes the pressure of the liquid in the cylinder to rise above atmospheric due to which the suction valve closes and the delivery valve opens. The liquid is then forced up the delivery pipe. And raised to the required height since during this operation of the pump the liquid is actually delivered to the required height, it is known as its delivery stroke. At the end of the delivery stroke the piston or plunger is at extreme left position, the crack is at 0 to 360 degree(i.e. at its inner dead centre) so that is has completed one full revolution, and both the suction and the delivery valves are close. This is in generating the working principle of reciprocating pump.

The gears are used to bear the load. Big gear wheel is connected to the pedal system. Seat and the pedals are of bicycle, but handle is bike handle. Crank shaft is the one of the important component. The rotary motion of the pedal is transformed to crank shaft. And the strong frame for the food stability here the power transmission system is gear drive system. When the piston rod travels to and fro motion the liquid from the water tank sucked and delivered through the sprayer with high pressure.

6.1 Calculation:

Length of the stroke = 6cm
Crank shaft radius = 3cm
Cylinder diameter = 5cm
Length of the cylinder = 11.5cm
Area of the cylinder $= \frac{\pi}{4} * d^2$
Discharge = ALN/60
A = area of the cylinder
L = length of the stroke
N = number of rotations of the crank
Q = ALN/60 m^3/sec
A = $\frac{\pi}{4} * d^2$

A = $\frac{\pi}{4} * (0.06)^2$ = 1.9625*10^{-3} m^2
L = length of the stroke = 6cm =0.06m
N = no of revolutions of crank per minute = 20rpm
Q = 1.963*10^{-3}* 0.06* 15 m^3/min
Q = 1.7667*10^{-3} m^3/min = 2.9445*10^{-5}m^3/sec
[1m3/sec = 1000000 ml/sec]
Q = 29.445 ml/sec = 1766.7 ml/min
Q = 1766.7 ml/min
Slip = Theoretical discharge – Actual discharge
= 1766.7-1200
= 566.7

% of slip = Theoretical discharge – Actual discharge
Theoretical discharge
=1766.7-1200
1766.7
= 0.3207 * 100
Percentage slip = 32.07%
Coefficient of discharge (C_d) =Actual discharge
Theoretical discharge
C_d = 1200/1766.7
C_d = 0.68

Power required driving the pump:
P = W*Q*(H_s+H_d) kw
W = weight of the water
Q = discharge
H_s = suction head
H_d = delivery head

W = mg
m = density * volume
Here taken the density of the water = 1000 kg/m^3
Volume of the cylinder = Area of the cylinder * height
= $\frac{\pi}{4} * d^2$ * h
= 1.9635*10^{-3} * 0.115
= 2.258 * 10^{-4} m^3
m = 1000 * 2.256 * 10^{-4}
m = 0.2258kg
W = mg
W = 0.2258* 9.81
W = 2.21 N
H_s = 20 inch = 0.508 m
H_d = 25 feet = 7.62 m
Q = 2.9445*10^{-5}m^3/sec
Power = W*Q*(H_s+H_d) kw
P =2.21 * 2.9445*10^{-5} (0.508+7.62)
P = 5.288 * 10^{-4} KW
Power = 0.5288 W

6.2Results:

Pedal powered sprayer was simple to operate initially but after filling up the suction and delivery pipes completely operator feel hard to give a complete rotation of the pedals but it is easy to operate using stepper mechanism. And the working pressure is more compare with the foot pump. Here the operator feel comfortable because the work performed by the operator by sitting on seat. There are three types of adjustments in the nozzle in spray gun. We measure the maximum pressures at three positions and the related diagrams are mentioned below.

Normally this position of the nozzle of used for spraying the fertilizers to the crops discharge in this case was less. And it is 1lt per minute with a maximum pressure of 50 kg/cm^2

Fig. 6.2: spray nozzle for crops

Normally this position of the nozzle of used for spraying the fertilizers to the trees discharge in this case was more than previous one. And it is 1lt 50 sec with a maximum pressure of 40-45 kg/cm^2

Fig. 6.3: spray nozzle for trees

Table 8.2: comparison between the results of foot & pedal operated sprayer

	Foot pump sprayer	Pedal powered sprayer
Height	1 meter	1.2 meter
Weight	10 kg	50 kg
Width	17cm	30cm
Delivery head	6 meter	7-8 meter
Suction head	0.508 meter	0.600 meter
discharge	1.2 lt/min	1.2 lt/min
transport	Easy	easy
working	Hard	easy
pressure	600 psi	710 psi
stability	Less	more

Conclusion:

Pedal operated sprayer is designed and fabricated successfully. It develops 45.69 to 49.21kg/cm^2 pressure used to spray fertilizers to trees & crops with adjustable nozzle. This is superior to existing sprayer viewed fro performance, stability & safety point of view.

REFERENCES

Nitin Das, Namit Maske, Vinayak Khawas, Dr. S. K. Chaudhary, Er. R. D. Dhete, 2015. *Agricultural Fertilizers and Pesticides Sprayers- A Review*, IJIRST – International Journal for Innovative Research in Science & Technology, 1: 11.

Malik, R.K., A. Pundir, S.R. Dar, S.K. Singh, R. Gopal, P.R. Shankar, N. Singh and M.L. Jat, 2012. *Sprayers and Spraying Techniques* – A manual, CSISA, IRRI and CIMMYT. pp: 20.

Shivaraja Kumar Pwarmeswaramurthy, 2014. Design and development of wheel and pedal operated sprayer", IPSJinternational journal of mechanical Engineering (IIJME), 2: 6.

Sandeep, H. Poratkar, Dhanraj R. Raut, 2013. "Development of Multinozzle Pesticides Sprayer Pump**",** International Journal of Modern Engineering Research (IJMER), 3(2): 864-868.

Varikuti Vasantha Rao Sharanakumar Mathapati Dr. Basavaraj Amarapur, 2013. "Multiple Power Supplied Fertilizer Sprayer**",** International Journal of Scientific and Research Publications, 3(8): 2250-3153.