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Design & Fabrication of Three Wheel Spray Pump

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Abstract-As on today the whole world is facing a problem of energy crisis. If we want to continue for prolonged use of energy then we must try to save it as much as we can whether it is on large scale or small scale. In today's world, we use various spraying technologies involving use of electrical energy, chemical energy of fuels. Thus in order to save the energy and natural resources it is very important to develop such machine that works without the use of these energies. Our project aims at the same objective and thus we developed such machine that operates on mechanical power. Along with saving the energy, the project will help the farmers to do spraying operations without expenditure of high manpower and the machine will give higher efficiency as compared to present method of spraying. Our current project will help the farmers for spraying but with certain research and modifications the project model can be used for spraying, weeding and seed sowing.

Key Words- Spray pump, Mechanization, slider crank mechanism

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 fromthese operations, spraying is also an importantoperation to be performed by the farmer to protect the cultivated crops from insects, pests, fungusesand diseases for which various insecticides,pesticides, fungicides and nutrients are sprayed oncrops for protection.[1] Farming has undergone a great evolution in last 50 years. Out of the variousreasons involved for this evolution is control ofvarious diseases on crops. During initial days therewas only hand spraying people use to do. Thenslowly there has been development of variousmethods to spray out chemicals and dusts.[1] Thoughthese devices were highly efficient, there is a needto have certain changes. Chemicals are widely usedfor controlling disease, insects and weeds in thecrops. They are able to save a crop from pest attackonly when applied in time. They need to be appliedon plants and soil in the form of spray, dust or mist.The chemicals are costly.[2]

Photograph 1.1 Backpack Type Spraying

Agriculture sector is facing problems with capacityissues, shrinking revenues, and labour shortages and increasing consumer demands. The prevalence of traditional agriculture equipment intensifies these issues. In addition, most formers are desperately seeking different ways to improve the equipment quality while reducing the direct overhead costs (labour) and capital. Thus, a significant opportunityrests with understanding the impact of a pesticide sprayer in an agriculture field.[2] 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.[2]

The argument for using existing conventional equipment is that farmers will face economical difficulties in case of chemical and electrical powered pumps as well as they will face difficulties in case of hand operated pumps. One way to overcome this problem is to use the equipment developed for application of the pesticides through the use of mechanical power. In selecting a pump for furnishing a supply of pesticides for farm use, or for spraying insecticides, herbicides or fungicides, we must be sure it is designed for the job to be done.[2] The pump should have sufficient capacity to supply the needed amount of water and spray material in the allowable time. Spraying is employed for a variety of purposes such as application of:

- Herbicides in order to reduce competition from weeds,
- Protective fungicides to minimize the effects of fungal diseases,
- Insecticides to control various kinds of insects, pests,
- Micro-nutrients such as manganese or boron.

The project model is created such that it can be used for spraying variety of crops.

2. PROBLEM SUMMARY

The farmers who use these types conventional backpack sprayer faces many types of problems like fatigue, tiredness, pain in spiral cord and muscles etc. Following problems can take place by use of this conventional type of pump:[3]

2.1 Common Problems

1) Heavy in weight causes difficulty in lifting manually.
2) Fatigue to the operator due to heavy weight.
3) Due to heavy weight during spraying, operator feel very tiredness and fatigue which reduces his efficiency.
4) Big size of pump cause inconvenience to the operator.
5) Poor selection and quality of equipment.
6) These problems combined with a lack of awareness and technical knowledge and inadequate maintenance and poor field use of equipment has led to unacceptable risks to environment and human health.

In our country farming is done by traditional way, besides that there is large development of industrial and service sector as compared to that of agriculture. The spraying is traditionally done by labour carrying backpack type sprayer which requires more human effort.[3] To overcome the above said problems, we made a sincere attempt to minimize human effort and scarce labour through design and development of the equipment which will be beneficial to the farmer for the spraying purposes.

2.2 Drawbacks of Existing Sprayer Pumps

The Indian farmers (small, marginal, small and marginal, semi-medium) are currently using lever operated backpack sprayer. A backpack sprayer consists of tank 10 -20 liter capacity carried by two adjustable straps. Constant pumping is required to operate this which result in muscular disorder. Also, the backpack sprayer can't maintain pressure, results in drifts/dribbling.[4] Developing adequate pressure is laborious and time consuming. Pumping to operating pressure is also time consuming. Moreover, very small area is covered while spraying. So, more time are required to spray the entire land. Back pain problems may arise during middle age due to carrying of 10-20 liter tank on back.

Photograph 2.1 Present Situation of Spraying Pump

2.3 Uneconomical Existing High cost Pumps for Indian Marginal and Small Farmers

Presently farmers are using knap-sack sprayer for spraying pesticides on crops in their farms which costs for Rs 1800-4500/-.Pesticides are diverse and omnipresent.This sprayer has a wide limitations and thus farmers can use the other sprayer also like bullock driven sprayer pump and tractor mounted sprayer.[4] Cost of bullock driven is about Rs 28000/-. But though this these sprayer has high advantages but are not affordable by farmers of developing nation .So, it's a need to find out a golden mean among these. The height factor also play a key role in spraying .For cotton, about 5 to 6 times spraying of pesticides is done. Cotton is one of the important commercial crops grown extensively in India. Over 4 million farmers in India grow cotton as their main source and income & livelihood. The textile sector, which is primarily based on cotton fibre, is the largest employer & income provider in India, second only to agriculture. It employs close to 82 million people – 35 million in textile & 47 million in allied sector

Table III flashes the light on No. of crops on which spraying is done and their horizontal, vertical distances and maximum height.[5]

3. DESIGN METHODOLOGY

3.1 Problem Statement

Agricultural sprayer vehicle should be able to work with help of appropriate controls in order to spray effectively along the path as required to perform the required functions. Based on these factor, the basic mechanical designs of agricultural sprayers vehicle will be designed and implemented for 3 liters of payloads by combining all the factor such as stated above with goal of achieving a better functionality.[6]

3.2 Objectives

1) Decrease the operational costs by using new mechanisms.
2) Work reliably as under different working condition.
3) Decrease the costs of machine.
4) Decrease labour costs by advancing the spraying methods.

3.3 Sub-Systems of the Machine[5]

3.3.1 Base frame or chassis

The base of frame of chassis is a mild steel fabricated structures that holds the entire assembly of the sprayers. It consists of one front wheel mounted on a shaft whose rotary motion is transmitted to the pump. It also has two rear wheels which are used to provide support to the back assembly.

3.3.2 Drive Assembly

The drive assembly consists of sprocket and chain mechanism. The sprocket is mounted on the shaft of front wheel and connected to the rear shaft by chain. Thus the motion is transmitted with the help of chain. Further the rotary motion is converted into reciprocating motion by slider crank mechanism.

3.3.3 Pump System

The pump systems comprises of sprayer mechanisms of 5litres capacity integrated with an inbuilt pump and sprayer.

3.4 Main Components of the Machine[6]

3.4.1 Nozzle

Nozzle is a device at the end of extension rod of pump which is used to spray the pesticides. Here the nozzles convert kinetic energy of fluid into pressure energy and release the fluid forcefully. The nozzle used in project is fibre ring nozzle.

Fig 3.1 Fibre Ring Nozzle

3.4.2 Pump Tubes

These are the plastic tubes whose one end is connected to the outlet of pump and other end is connected to the nozzle. The pesticide from tank is transferred to the nozzle with the help of these tubes.

Fig 3.2 Extension Tube

3.4.3 Tank

It is a 5 lit. capacity tank made up of plastic in which the pesticide can be stored.

Fig 3.3 knapsack pump

3.4.5 Piston

The piston is fitted inside the tank. The up and down movement of the piston creates vacuum inside the tank and thus pressure is created.

3.4.6 Slider Crank Mechanism

The mechanism consist of a crank and connecting rod. These two are connected in such a way that the

rotary motion of the shaft is converted into reciprocating motion the piston.

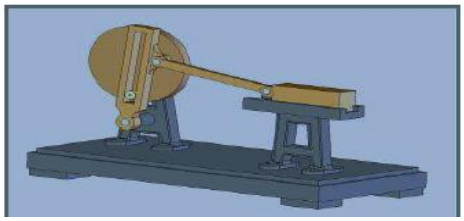

Fig 3.4 Slider Crank Mechanism

3.4.6 Sprocket & Chain

It is a drive mechanism in which motion is transferred.

3.4.7 Wheels

wheel is a circular component that is intended to rotate on an axial bearing. The wheel is one of the main components of the wheel and axle which is one of the six simple machines. Wheels, in conjunction with axles, allow heavy objects to be moved easily facilitating movement or transportation while supporting a load, or performing labor in machines. Wheels are also used for other purposes, such as a ship's wheel, steering wheel, potter's wheel and flywheel.

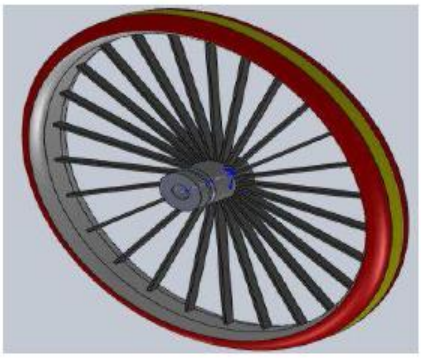

Fig 3.5 Wheel

4. 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.[6]

5. ANALATICAL CALCULATIONS

Sr. No.	*Particulars*	*Value*
1.	Speed of the main wheel	25 rpm
2.	Speed of the sprockets	60 rpm
3.	Length of the connecting rod	440 mm
4.	Distance between the wheel and the smaller sprockets	500 mm
5.	Distance between the sprockets and the reciprocating pump	46 cm
6.	Length of the crank	16 cm
7.	Stroke length of the reciprocating pump	18 cm
8.	Discharge through the nozzle per rotation of pump	6.38 ml/stroke
9.	Pump stroke per rotation of wheel	3
10.	In ideal condition rate of discharge through the pump	1.58 lit/min
11.	In working condition rate of discharge through the pump	0.166 lit/min
12.	Rotation of wheel per minute	22 rpm
13.	Delivery of pesticide per stroke of the pump	7 ml
14.	Delivery of pesticide per rotation	12 ml
15.	Delivery of pesticide from 2 nozzles	7 ml/stroke
16.	Delivery of pesticide from 1 nozzle	2.68 ml/stroke
17.	Diameter of front wheel	70 cm
18.	Diameter of rear wheels	41 cm
19.	Diameter of larger sprocket	22 cm
20.	Diameter of smaller sprocket	8.5 cm

Table 5.1 Calculations of machine operation

- ***Selection of Reciprocating Pump***

Speed of Crank N=122 rpm
Required Discharge (with one nozzle)
Q = 3 Lit/min = 0.0166 m^3/sec

Assuming Ratio,
Length/Diameter= 2.769
Q = ALN/60……. for single acting
Q = 2ALN/60…….... for double acting
Where,
A = Area of piston = 331830.72 mm
L = Length of stroke=180 mm
D=diameter of piston = 650 mm

Speed of piston or RPM ofcrank= 122 rpm

Q = 2ALN/60
Q = 2×18×10-2×(π/4)×(65×10-2)×122/60
Q = 2×1.39 m^3/sec
For…… Q = 1 Lit = 3000 cm^2
Q = 2×1.39×60 = 166.84 m^3/min
Q = 0.166.8 lit/min
L= 180mm
D= 65mm

So, pump having the diameter 18 cm and length 65 cm is chosen

6. APPLICATIONS

1) For the insecticides application to control insect pests on crops and in stores, houses, kitchen, poultry farms, barns, etc.
2) For the fungicides and bactericides application to control the plant diseases.
3) For the herbicides application, to kill the weeds.
4) For the harmony sprays application to increase the fruit set or to prevent the premature dropping of fruits.
5) For the application of plant nutrients as foliar spray.
6) For applying the powdery formulation of poisonous chemicals on the crops and for any other purposes.

Along with the above mentioned applications, our model is designed in such a way that it can be used for spraying variety of crops as follows;

Sr. No.	***Name of crop***	***Distance between plants (Horizontal/vertical)***	***Height of crop***
1.	Sorghum	15 inch /3-4 inch	5.5-7 feet
2.	Pearl millet	15 inch /3-4 inch	5.5-7 feet
3.	Sugarcane	15 inch /3-4 inch	5.5-7 feet
4.	Soybean	15 inch / 2 inch	5.5-7 feet
5.	Corn	15 inch /3 inch	5-7 feet
6.	Groundnut	15 inch /3 inch	1.5 feet
7.	Cotton	24-36 inch /24-36 inch	2-5 feet
8.	Pigeon Pea	15 inches / 6 inches	3-4 feet
9.	Wheat	40-50 cm	60-100 cm
10.	Paddy	40-60 cm	60-100 cm

Table 6.1 Distance between plants of crops

7. COMPONENT MATERIAL & COST ESTIMATE

7.1 Components &it's Materials

Component	***Material***
Tank	Plastic
Lid or Cap	Plastic
Pressure Chamber	Plastic
Crank & Connecting Rod	M.S.
Piston ring	Rubber
Body	Brass / Engg. Plastic
Nozzle	Plastic
Pipe/tubes	Plastic
Frame	C.R.C.
Shaft	M.S.
Front Wheel	Steel
Rear Wheel	Plastic
Adjustment Rod	M.S. Square Pipe

Table 7.1 Components &it's materials

7.2 Cost Estimate

Item Description	***Quantity***	***Estimated Cost***
Main Structure	1	1500
Front Wheel	1	150
Rear Wheels	2	100
Shaft	2	80
Sprocket	2	100
Bearings	3	450
Nozzle	6	120
Pipe	1	140
Connecting Rod	1	40
Crank	1	20
Tank	1	2000

Table 7.2 Cost Estimate

8. CONCLUSION

- The suggested model has removed the problem of back pain, since there is no need to carry the tank (pesticides tank) on the back.
- As suggested model has more number of nozzles which will cover maximum area of spraying in minimum time & at maximum rate.
- The c.f. valves can also be applied which help in reducing the change of pressure fluctuation and c.f. Valves helps to maintain pressure.
- Proper adjustment facility in the model with respect to crop helps to avoid excessive use of pesticides which result into less pollution.
- Imported hollow cone nozzles should be used in the field for better performance.
- Muscular problems are removed and there is no need to operate the lever.
- This alone pump can used for multiple crops

Thus the developed model has been tested successfully and the observations has been noted down. The most important benefit of the model is that it is very cost effective as compared to other machenaries available in the market. This will help poor farmers to use the machine and cover large area for spraying. The fabricated model has overcome all the problems stated above. Although the same models had been fabricated before, certain modifications had been made due to which the machine has become more efficient. The modifications are as follows;

1) Horizontal and vertical adjustments of the nozzle is introduced so that the machine could cover more area and variety of crops can be sprayed.
2) Fibre ring Nozzle is used due to which the spray area can be adjusted as required.
3) Large size chain is used so that less force is required push the machine.

9. FUTURE SCOPE

Near about 50-60% of Indian occupation depends on farmers. India is under-developed country and many farmers cannot afford costlier machines for these operations. Several modifications can be made to improve the performance of proposed model. The modifications can be as follows;

1) Solar energy can be used instead of mechanically pushing the vehicle.
2) Sensors can be used so that the movement of the vehicle can take place automatically.
3) Al (Artificial Intelligence) can be introduced in near future with less inverstement.

10. PROJECT MODEL

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