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Experimental Investigation of Agricultural Sprayer and Weeder

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ABSTRACT: In agricultural sector 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, these problems can be overcome by using agricultural reciprocating multi sprayer. It facilitates uniform spread of the chemicals, capable of throwing chemicals at the desired level, precision made nozzle tip for adjustable stream and capable of throwing foggy spray depending on requirement. In our project we use slider crank mechanism to convert rotary motion into reciprocating motion to operate the pump, thus the pesticide is spread through the nozzle. This work gives continuously flow of pesticide at required pressure and height. A special arrangement is implemented in this project to adjust the pressure as high or low. We also use a weed cutter in our model for removing unwanted plants. By using agricultural sprayer, spraying time and weeding time, human efforts reduces and results in cost reduction.

KEYWORDS: Cost, Nozzles, Pump, Spraying time, Weed cutter.

I. INTRODUCTION

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. Although sprayers varies like motorized, hand operated. Spraying pesticide is an important process in farming. Now days, there are many types of pesticide sprayer already in market. For the different types of pesticide sprayer there are have a different shapes, sizes, method to carry it but the function are same. 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 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; 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. The mechanism involve in this sprayer is reciprocating pump, and nozzles which were connected at the front end of the spraying equipment. A special arrangement is implemented for adjusting the pressure as low and high with the help of adjusting the nut. Also the weeding is done by this equipment.

II. LITERATURE REVIEW

a) Existing Spraying Methods:

One of the more common forms of pesticide application, especially in conventional agriculture, is the use of mechanical sprayers.

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1. Backpack (Knapsack) Sprayer:

One type of backpack sprayer is a compressed air sprayer with a harness that allows it to be carried on the operator's back. Another type of backpack sprayer has a hand-operated hydraulic pump that forces liquid pesticide through a hose and one or more nozzles. The pump is usually activated by moving a lever. A mechanical agitator plate may be attached to the pump plunger. Some of these sprayers can generate pressures of 100 pounds per square inch (psi) or more. Capacity of both these types of backpack sprayers is usually 5 gallons /less.



Fig 1: Backpack Sprayer

2) Lite-Trac:

Lite-Trac is a trading name of Holme Farm Supplies Ltd, a manufacturer of agricultural machinery registered in England and based in Peterborough. The Lite-Trac name comes from "lite tractor", due to the patented chassis design enabling the inherently very heavy machines manufactured by the company to have a light footprint for minimum soil compaction.

Holme Farm Supplies Ltd agricultural products, sold under the Lite-Trac name, include tool carriers, self-propelled lime and fertilizer spreaders, sprayers, granular applicators and tank masters. The company's products are identifiable by the combination of unpainted stainless steel tanks and booms with bright yellow cabs and detailing.

A Lite-Trac crop sprayer, or liquid fertilizer applicator, mounts onto the SS2400 Tool Carrier centrally between both axles to maintain equal weight distribution on all four wheels and a low centre of gravity whether empty or full. The stainless steel tanks are manufactured in capacities of up to 8,000 liters, whilst Pommieraluminium booms of up to 48 meters can be fitted, making these Europe's largest four-wheeled self-propelled sprayers.



Fig 2 : Lite-Trac

3) Motorcycle Driven Multi-Purpose Farming Device (Bullet Santi):

In 1994, Mansukhbhai Jagani, developed an attachment for a motorbike to get a multi-purpose tool bar. It which addresses the twin problems of farmers in Saurashtra namely paucity of laborers and shortage of bullocks. This motor cycle driven plough (Bullet Santi) can be used to carry out various farming operations like furrow opening, sowing, inter-culturing and spraying operations. Mansukhbhai's intermediate-technology contraption proved efficient and cost-effective for small-sized farms.

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Vol. 8, Issue 3, March 2019



Fig 3: Bullet Santi

b) Conclusion from Existing Spraying Methods.

- Mechanisation for spraying operation is costlier for specialised operations such as High pressure sprayer, Engine operated sprayer.
- Skills of labour required depends upon the complexity of the equipment machinery used.
- All the pre-existing methods have concentrated on providing feasible easy solutions to reduce cost of production by reducing cost of mechanisation and increasing productivity.

III. AIM AND OBJECTIVES

Aim :

The ultimate aim of this project is that the farmer need not carry the entire pesticide sprayer pump on his shoulders but just pull the mechanism mounted on the trolley to operate the pump and spray the pests. This makes the farmer feel comfortable, relaxed and less tiresome. The second aim is to reduce human efforts due to the constant pumping action for creating pressure inside the pesticide sprayer and thereby provide a suitable environment for the user reducing the fatigue load acting on the body.

Objectives:

1. To increase efficiency of sprayer.
2. To decrease the operational cost by using new mechanism.
3. To remove backpack and foot spraying techniques.
4. To reduce labour cost by advancing the spraying method.
5. To save the time of the farmers.

IV. PROBLEM SPECIFICATIONS

The major problems being faced currently are:

- Heavy Load to be carried on Shoulders
- Continuous Pumping using one Hand
- Direct Contact with the Hazardous Chemicals
- Random Spraying of Pesticides on Crops

V. METHODOLOGY

- Data collection will be done by literature survey, user study and market study through questionnaires, videos and observation etc
- QFD generation based on the user requirements and corresponding technical requirements, and PDS will be generated prioritizing the features in the QFD.
- Concepts will be generated by sketching and digital Modeling.

International Journal of Innovative Research in Science, Engineering and Technology

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Vol. 8, Issue 3, March 2019

- Generate the doodle sketches and come out with five concepts and the digital model will be created with the detailed features using Creo software.
- Concept evaluated and final concept selected using weighted ranking method.
- Working model will be made with detailed features and feedback were collected.

.VI. CONSTRUCTION

The main components of agricultural sprayer are as follows:

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 slip.

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 to reciprocating motion of pump and extension rod.

Connecting rod:

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

Pump:

It consist 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:

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.

Wheel:

Wheel is used to carry the whole assembly and move machine from one place to another by rotary motion of it. A bike wheel is a wheel, most commonly a wire wheel, designed for a bike. Bike wheel is designed to fit into the frame and fork via drop outs, and hold bike tyre. 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.

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

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

International Journal of Innovative Research in Science, Engineering and Technology

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Vol. 8, Issue 3, March 2019

VII. WORKING

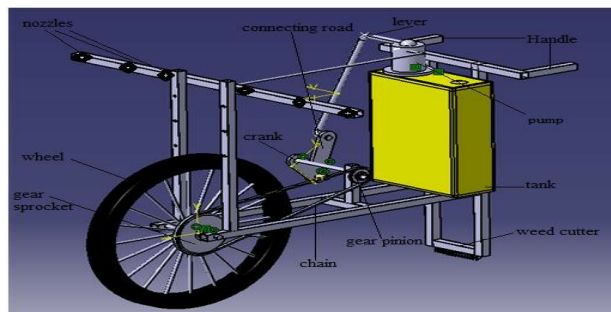


Fig 4: Agricultural Sprayer

Above figure shows the assembly of the agricultural sprayer. The operator grabs the handle and pushes the cycle forward as cycle moves forward, the wheel rotate. When the wheel rotates then the gear sprocket mounted on wheel is also rotate at same speed. The chain drive transfers the motion of gear sprocket to pinion sprocket. The pinion sprocket and crank is mounted on either side of same shaft, the rotary motion of shaft is converted into the reciprocating motion with the help of crank and connecting rod mechanism. The connecting rod is also connected with lever and then the lever oscillates at fulcrum. The piston connected at fulcrum produce reciprocating motion in cylinder and the required pressure is achieved. The pesticide from tank sucks in cylinder and piston forced the pesticide to nozzle through the pipe; the numbers of nozzles are connected to spray the pesticide. We can adjust the pressure, which is required for spraying with the help of special arrangement is to change the length of crank by providing slot on crank. By providing some adjustment at joint of connecting rod and lever free rotation of crank or neutral position can be achieved. Using these adjustments pumping is stop and the wheel rotate freely when you need not spray pesticide. Height, position and angle of the nozzle can be adjustable.

VIII. DESIGN CALCULATION

a) Specifications:

- Length of frame ,L= 915 mm.
- Rear portion breadth frame , B_1 = 460 mm.
- Front portion breadth frame , B_2 = 270 mm.
- Height of frame ,H= 640 mm.
- Holding rod length = 385 mm.
- Maximum height of spraying , H_{max} = 770 mm.
- Stem height of back portion ,h= 305 mm.
- No .of teeth in gear sprocket , Z_1 = 45 teeth.
- No .of teeth in pinion , Z_2 = 14 teeth.
- Diameter of gear sprocket ,D = 190 mm.
- Diameter of pinion , d =80mm.
- Length of tank holder ,l= 355 mm.
- Breadth of tank holder ,b=175 mm.
- Stroke length of crank = 80 mm.
- Tank capacity =16 litres.
- Frame to Tank holder length =210 mm.
- Distance between gear sprocket and pinion. = 400 mm
- Connecting rod length = 650 mm.
- Wheel diameter =60 mm.

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Vol. 8, Issue 3, March 2019

b) Part Design :

1. Selection of Wheel:

Distance between two plants = 1.5 feet = 46cm.

Line covered by one rotation of wheel = 4

$$46 * 4 = 184\text{cm}$$

$$184 = 2\pi r$$

$$r = 184 / 2\pi$$

$$r = 30 \text{ cm}$$

The diameter of wheel = 60 cm.

2. Selection of Pinion:

Minimum no. of teeth available on pinion = 14

Outer dia. Of pinion = 8 cm = 80 mm

Inner dia. Of pinion = 6.5 cm = 65mm

$$\text{Pitch circle dia. (} D_p \text{)} = \frac{D_o - D_i}{2} + (D_i)$$

$$D_p = 72.5 \text{ mm}$$

$$\text{Gear Ratio} = 1:3$$

On rotation of gear sprocket gives three rotation of pinion sprocket, we required three strokes to generate adequate amount of pressure.

3. Selection of Gear Sprocket:

$$1/3 = 14 / t_g$$

$$t_g = 14 * 3$$

$$t_g = 42$$

$$\frac{t_p}{t_g} = \frac{D_g}{D_p}$$

$$D_g = 218 \text{ mm}$$

$$\text{Pitch} = \frac{\text{Number of teeth on pinion}}{\text{pitch circle diameter of pinion}} = \frac{14}{72.5} = 0.25 \text{ mm}$$

4. Selection of Chain:

Chain type roller chain

ISO Chain no. 05B

pitch = 0.25 mm

Length of chain , L = K.P

No. of chain ,

$$K = \frac{T_1 + T_2}{2} + \frac{2X}{P} + \frac{T_2 - T_1}{2\pi} * \frac{P}{X}$$

$$K = ((14+42) / 2) + ((2*479) / 0.25) + ((42-14) / 2\pi)(0.25/479)$$

$$K = 28 + 3832 + 0.0023$$

$$K = 3860 \text{ mm.}$$

$$L = K * P$$

$$L = 3860 * 0.25 \text{ L} = 965 \text{ mm}$$

$$L = 96.50 \text{ cm.}$$

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Vol. 8, Issue 3, March 2019

5..Design of Frame:

Length of frame = (centre dist. between two sprockets) + (width of tank) + (Excess)

$$= 400 + 175 + 340$$

$$L = 915 \text{ mm}$$

Height of Frame = 640 mm

Width of Frame = 460 mm

Total length of pipe = 1000 mm

Cross section area of circular pipe
= $(3.14 \times 20^2) / 4 = 314.15 \text{ mm}^2$

Volume of frame = $314.15 \times 1000 = 314159 \text{ mm}^3$

Density of M. S. material = $7.7 \times 10^{-6} \text{ kg/mm}^3$

$$\text{Density} = \frac{\text{mass}}{\text{volume}}$$

Mass = density * volume

$$= (7.7 \times 10^{-6}) \times 314159$$

$$= 2.42 \text{ kg}$$

Total weight of assembly = $15 + 2 + 1 + 9$

$$= 27 \text{ kg} \times 9.81 = 264.87 \text{ N}$$

Yield stress of material = 247 N/mm^2

Area = $3.14 \times 20 \times 1000 = 62800 \text{ mm}^2$

Load

Stress = $\frac{\text{Load}}{\text{Area}} = \frac{264.87}{62800} = 0.0039 \text{ N/mm}^2$

Therefore, $0.0039 < 247 \text{ N/mm}^2$, hence the design is safe.

6. Design of Crank and Connecting Rod by Using Synthesis of Mechanism (Three Position Method):

Crank, AB = 8 cm .

Connecting Rod, BC₁ = 65 cm

7.Selection of Pump:

We are going to join six nozzles then pump required to produce the discharge is,

$$(6) \times (0.3333) = 2 \text{ lpm}$$

Total discharge of pump is 2 lpm.

For above discharge, which pump give pressure above 2 bar is to be selected.

6.Nozzle Selection:

Diameter of wheel = 50 cm

Let's consider farm of 1 Acre, Therefore,

1 acre = 4046.86 m^2

$$L = \sqrt{4046.86} = 64 \text{ m}$$

Number of plants in 64 meters,

$$N_p = \frac{64}{0.33} = 168$$

From survey earlier when hand backpack spray pump used then 60 ltr. of pesticide are used for 1 acre farm.

Consider 60 ltr. of pesticide is required for 1 acre farm so how much amount of pesticide is required for one plant.

Total number of plants in 1 acre,

$$168 \times 168 = 28224$$

60 ltr. for 1 acre,

$$\frac{60}{28224} = 2.1258 \times 10^{-3} \text{ ltr/plant.}$$

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Vol. 8, Issue 3, March 2019

Consider time required for 1 acre farm to spray a pesticide is 3 hrs.= 180 minute=180/28224

$$=6.3775 * 10^{-3} \text{min/plant}$$

$$=1/6.3775 * 10^{-3}$$

$$= 156.8 \text{ plant/min.}$$

Discharge=

$$\text{Discharge} = 0.3333 \text{ ltr./min.}$$

$$(2.1258 * 10^{-3}) * (156.8)$$

Find the pressure drop,

$$\left(\frac{Q_2}{Q_1}\right)^5 = \left(\frac{P_2}{P_1}\right) \quad (P_2) = (P_1) * \left(\frac{Q_2}{Q_1}\right)^5 = (2) * \left(\frac{0.3333}{0.4166}\right)^5$$

$$P_2 = 1.279 \text{ bar}$$

Pressure drop = 0.72 bar

IX. 3D CAD MODELS

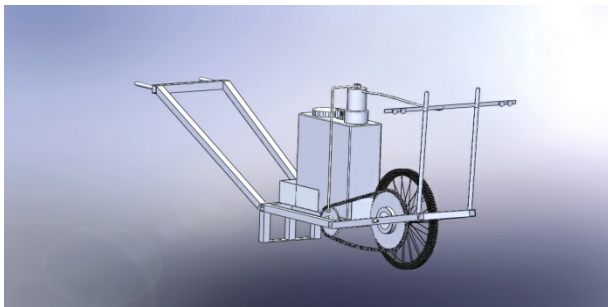


Fig 5 : Assembly Model

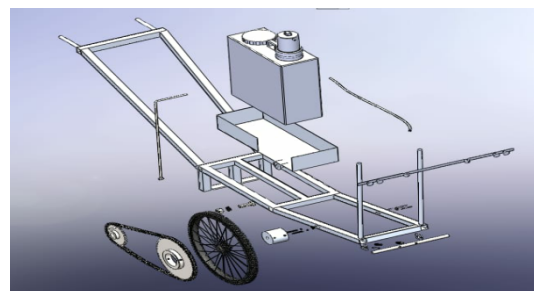


Fig 6: Exploded view

X. CONCLUSION

The equipment is purposely design for the farmers having small farming land say 5-6 acre. It is suitable for spraying as well as weeding at minimum cost for the farmer so that he can afford it. The equipment will results more beneficial when it is subjected to moist soil for weeding purpose, due to moist soil the weed cutter can easily penetrate and dig out the soil and hence will easily accomplished the weeding process. The performance of the equipment will increase when it is operates on the smooth surface or less uneven surface and also it will be more effective when it is used on the crops having nearly similar height and having the less space between two crops.

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