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Design and Fabrication of Manually Operated Multi-nozzle Spray Pump

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Abstract
Automation for spraying in the field of agriculture has increased the productive output of the farms.
Owing to this, labour problem has been solved. But the scenario in the country like India is different.
In the agriculture field, automation in such places is a difficult task also the economic condition of majority of Indian farmers is not well to do. Therefore, the manually operated sprayer finds wide application in such condition. Small scale farmers are very interested in manually lever operated knapsack sprayer because of its versatility, cost and design. In Indian farms two types of sprays are used: Hand operated and Fuel operated pump. The main drawn back of hand operated spray pump is that the user cannot use it for more than 5-6 hours continuously as he gets tired whereas fuel operated spray pump requires fuel which is expensive and availability of fuel is not easy at rural places.
This paper suggests a model of manually operated multi nozzle pesticides sprayer pump which will perform spraying at maximum rate in minimum time without necessity of fuel to operate and also reduce the fatigue to the farmer.
Keywords: Knapsack, Agriculture Field, Multi-nozzle, Pesticides, Pump etc.

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I. INTRODUCTION

India is set to be an agricultural based country approximately 75% of population of India is dependent on farming directly or indirectly. Our farmers are using the same methods and equipment for the ages e.g. seed sowing, spraying, weeding etc. There is need for development of effective spraying and weeding machine for increasing the productivity. India is a land of agriculture which comprises of small, marginal, medium and rich farmers. Small scale farmers are very interested in manually lever operated knapsack sprayer because of its versatility, cost and design.

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 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. In Agricultural sector use of cheap and beneficial equipment for effective spraying for increase productivity which is very important for better contribution for India's GDP.

1.1 Problem Statement

A backpack sprayer consists of tank 10 -20 liter capacity carried by two adjustable straps. Constant pumping is required to operate this which results in muscular disorder. Also the backpack sprayer can't maintain pressure, results in drifts/dribbling .Developing adequate pressure is laborious and time consuming. Moreover, very small area is covered while spraying. So, time consuming process.

1.2 Scope & Objective

- Work reliably under different working conditions.
- Decrease labor cost by advancing the spraying method.
- Machine can be operated in small farming land (5 acre).
- Making such a machine which can be able to reduce spray time.
- Maximum area of spraying in minimum time.
- Proper adjustment facility with respect to crop size & height.
- Attach the multiple nozzle & trolley.
- System is eco-friendly by using a spray guard for spraying.

II. METHODOLOGY

Multi sprinkle system work on principle of reciprocating pump. This reciprocating pump uses single slider crank mechanism, in which small sprocket mounted on another shaft works as crank. There are two sprockets which is mounted on two different axles in which one sprocket is directly attached to wheel axle. Connecting rod is attached to another sprocket axle through disc. In this power is given to piston of reciprocating pump through rotation of wheel.

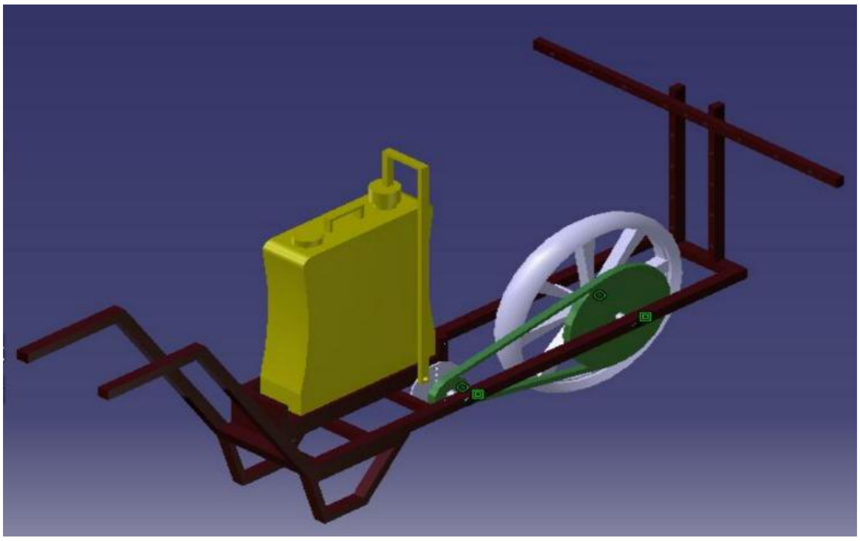

Fig- 1: Multi-Nozzle Wheel Spray Pump.

2.1. Construction

2.1.1. 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.

2.1.2. 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.

2.1.3. 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.

2.1.4. 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.

2.1.5. 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.

2.1.6. 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.

2.1.7. 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 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.

2.1.8. 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.

2.1.9. 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**.**

2.2 Working:
Multi sprinkle system work on principle of reciprocating pump. This reciprocating pump uses single slider crank mechanism, in which small sprocket mounted on another shaft works as crank. There are two sprockets which is mounted on two different axles in which one sprocket is directly attached to wheel axle. Connecting rod is attached to another sprocket axle through disc. In this power is given to piston of reciprocating pump through rotation of wheel.

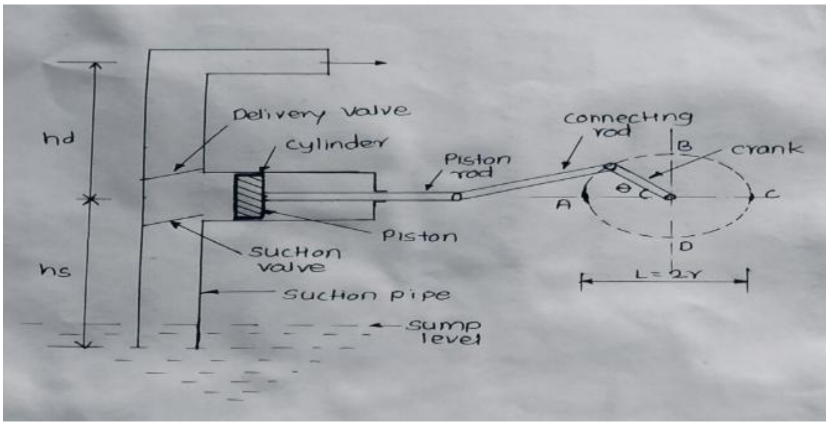

Fig No. 2: Slider crank mechanism (Pumping)

III. DESIGN CALCULATIONS:

3.1. Selection of Wheel-

Distance between two plants = 1.25 feet = 38 cm.
Line covered by one rotation of wheel = 4
38 * 4 = 152 cm
152 = 2πr
r = 152/2π
r = 25 cm
The diameter of wheel = 50 cm

3.2. Design of Chain and Sprockets:

Transmission ratio (i) = 3

Select the number of teeth on small diameter sprocket for the transmission ratio of 3 from the PSG Design data book.

z1= 25
z2= i × z1

z2= 3*25
z2=75 .....(z2 max = 100 to 120, hence safe)

Now, to find the pitch of chain,
Formula for optimum centre distance is,

CD= (30-50) P .....(p= pitch, from PSG design data book)

Assuming CD as 500 mm, therefore,

500= (30-50) p
∴ p= 500/30 or 500/50
∴p= 10 to 16.66

From PSG design data book, select suitable value for pitch
Hence pitch p= 12.7

Select suitable chain type according to pitch selected from design data book,
Chain type 08A-1 R40 (R for simplex type)
Pitch 12.7 mm
Roller diameter 7.95 mm
Bearing area 0.44 cm2
Breaking load 1410 kgf

Now, calculate number of links and chain length.
Relationship between centre distance and length of chain is,

Lp = 2(ap)(p) + (z1+z2)/2 + (z2-z1/2)2 /ap ......(PSG design data book)

Lp = number of links
ap= approximate CD in multiples of pitches = a0/p
a0= initially assumed CD

ap = 500/12.7 = 39.37
∴ Lp = 2(39.37) + (25+75)/2 + (7.95/39.37)2
∴Lp = 78.74+50+1.608
∴Lp = 130.34 ...... (Take 132)

Actual length of chain = Lp*p = 132 × 12.7 = 1676 mm = 1.6 m
Check for the actual centre distance (a),
a = e+ (p)× (e2-8m)/ 4 ......(From PSG design data book)

e = Lp – (z1+z2)/2 ......(Constant)
e = 132 – (25+75)/2
e = 82
m= $\{\frac{z2-z1}{2\pi}\}$ ......(Constant)

m = $(50/2\pi)^2$
m = 63.32

∴ a = {82 + 822 - 8×63.32}/4 ×12.7

∴ a = 510.70 mm
Take Centre Distance as 510 mm for design.

Now, Find the Pitch circle diameter of sprockets,
PCD = p / {sin(180/z)} .....(PSG design data book)

PCD for small sprocket
D1 = 12.7 / {sin (180/25)}
D1 = 82.4 mm

PCD for big sprocket
D2 = 12.7 / {sin (180/75)}
D2 = 247.2 mm

Calculating PCD considering roller diameter (dr),
For small sprocket,
∴d1 = D1 + 0.8 × (dr)
∴ d1 = 8.24 + 6.36
∴ d1 = 146 mm

For big sprocket,
∴ d2 = D2 + 0.8 × (dr)
∴ d2 = 24.72 + 6.36
∴ d2 = 310.8 mm.

3.3. Design of Frame:
Length of frame = Centre Distance + Length of pump + Excess
= 510 + 500 + 240
= 1250 mm
Width of frame = 250 mm
Length of handle = 500 mm
Length of grip = 150mm

Material used for frame is hollow M.S. bar of 30 × 2 mm

c/s area of frame = 302 – 262 = 224 mm2.

Total length of material used for frame,
= 1250×2 (length) + 250×2 (width) + 500×2 (handle) + 150×2 (grip)
= 4300 mm

Volume of frame = 4300×224 = 963200 mm3

Density of material= 7.7 × 10^-6kg/mm2
Density = Mass / Volume
∴Mass = Density × volume = = 7.7 × 10^-6 × 963200

∴Mass of frame = 7.4 kg
Total force exerted by frame = 7.4 × 9.81 = 72.6 N
Total force by whole assembly = 22 kg (pump) + 3 kg(mech components) + 7.4 kg(frame) × 9.81
= 317.844 N

Yield stress for m.s. =247 Mpa
Stress developed =Total Load / cs area of frame
= 317.844 / 224
= 1.41 N/mm2 << 247 N/mm2
Hence the design is safe.

3.4. Design of nozzles:
Pump used for spraying is of 20 liters generating pressure of 2-4 bar.
For this pressure range we selected Italian nozzles with ATR-60 nozzle spraying system

ATR-60 resembles the spray angle by a nozzle i.e. 600.

For 5 bar pressure,the discharge for yellow nozzle is 0.73 lit/min
∴For 1 bar pressure, discharge will be = 0.73/5 = 0.146 lit/min.
∴ For pressure of 2 – 4 bar actually developed in the pump, the discharge will be,
= 0.146 × 4
= 0.584 lit/min

Type of nozzle	Discharge at given pressure
Albuz ATR-60	0.584 lit/min/nozzle

Table No. 1 Specifications of ATR 60.

We use six nozzles to obtain spray,
∴ Discharge = 0.584 × 6
∴Discharge = 3.504 lit/min

Capacity of pump = 20 liters.
∴ time required for six nozzles to spray 20 liters ,
= 20/3.5
= 5.71 or 6 minutes.

Distance between two nozzles = 1.25 ft = 38 cm = 0.38 m
Length of strip supporting nozzles = 0.38 × 5 = 1.9 m

IV. RESULT AND DISCUSSION.

- **Simulation & Analysis:**

Component 1 – The Frame
The load of pump of 196 N acting in downward direction, causes stress concentration in the component, which resulted in bending of component with ares having maximum stress concentration. After simulation the results were,

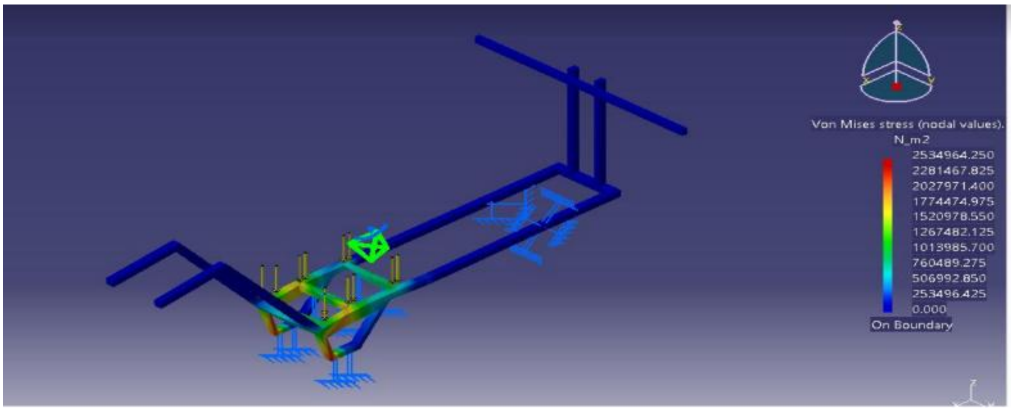

Fig No. 3: Von Misses analysis

Result –
Maximum nodal value applying Von Misses stress is 2.54 N/mm2
.
Allowable yield stress of frame material is 247 N/mm2
∴ 2.54 N/mm2 << 247N/mm2

Component 2 – Support for Pump

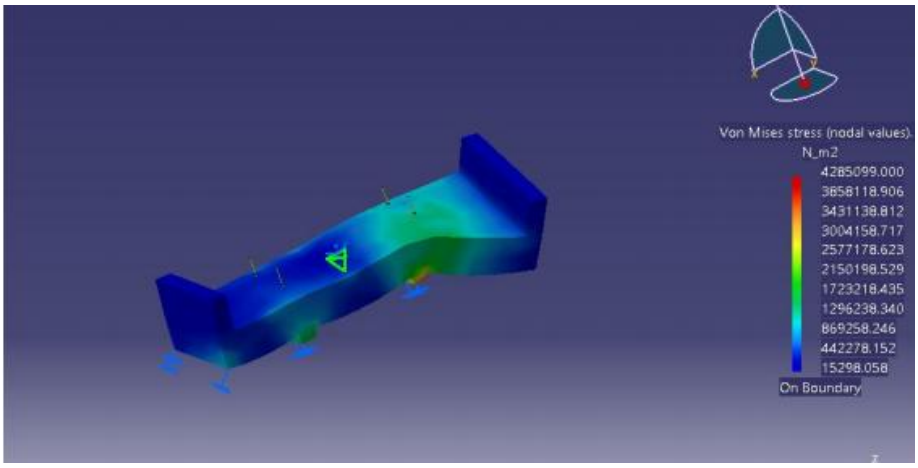

Fig No. 4: Von Misses stress analysis

Result –
Maximum nodal value applying Von Misses stress is 4.5 N/mm^2
Allowable yield stress of frame material is 247 N/mm^2
∴ 4.5 N/mm^2 << 247N/mm^2

V. FUTURE SCOPES

- Work reliably under different working conditions.
- Decrease labor cost by advancing the spraying method.
- Machine can be operated in small farming land (5 acre).
- Making such a machine which can be able to reduce spray time.
- Maximum area of spraying in minimum time.
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- Attach the multiple nozzle & trolley.
- System is eco-friendly by using a spray guard for spraying.

VI. CONCLUSIONS

It is upgraded design of manually operated sprayer which will be helpful for small land farmers. It consumes less time and saves money as compared with conventional spraying and weeding. This machine does not require any fuel or power so maintenance is less.

• The suggested model has removed the problem of back pain, since there is no need to carry the tank on the backbone and solder.

• More no.of nozzle which cover maximum area of spray in minimum time at maximum rate.

• 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 nozzle should be used in the field for the better performance.

• Muscular problem is removed and there is no need to operate lever.

• This alone pump can use for multiple crops.

• It is little heavy but efficiently working in rough conditions of farm. It is economical therefore affordable for all kind of farmers.

• It requires comparatively less time for spraying so we can get more fields spraying per day. It is cost effective than the existing spraying pumps available in the market as no direct fuel cost or cost for maintenance is needed for this.

• 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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