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Design and Working of Adjustable Manually Push Operated Pesticide Spraying Machine

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Abstract - *Agriculture has been the backbone of Indian economy. But advancement and mechanization of agricultural tools is slow as compared to other sectors. There are many areas in agricultural sector where speed of modernization is quiet slow. One of the main sectors is pesticide spraying machine. By modernization in this sector pesticides can be evenly distributed on farms which will reduce wastage of pesticide and hence prevents wastage of inputs applied on farms which reduces cost of production. One such machine is developed in which height of sprayers, horizontal adjustments of nozzles and self-adjusting power driven mechanism is developed. This mechanism is free of fuel and its operation is easy and painless. This is first four wheeled pesticide sprayer is developed as a step towards modern farming.*

Key Words: **Agricultural sector, Modernization Indian Farming, Pesticide spraying machine, self-adjusting, Mechanization, four wheeled, Modern farming.**

1. NEED OF THIS PESTICIDE SPRAYING MACHINE

Farming is called as backbone of Indian economy. And pesticide spraying is most important part of agriculture. Traditionally, farmers are using backpack sprayer which is hand operated portable machine. Labour has to carry the weight of pesticide filled tank on their back which causes fatigue to labour and hence reduces the human capacity. Based on survey reports of farmers, gardeners and researchers, we find following problems in current available pesticide spraying machine. It leads to severe problems of back pain to farmers. It requires more time to spray pesticide over a wide area of farm land.

Some innovative sprayers are also developed but they occupy large space which is main drawback. Existing modern sprayers also leads to wastage of pesticides on fields. It requires more time to spray pesticide over a wide area of farm land; they are not adjustable in sense of height, and not suitable for Indian style of farming. They require fuel for their working.

We have seen above drawbacks and limitations of traditional as well as advanced sprayers. So there is a need of time to develop such a pesticide spraying machine which removes or decreases the limitations of above all sprayers. So this project is going to be manually push operated adjustable, efficient, and time saving, pain relieving.

2. DEVELOPMENT OF THIS PESTICIDE SPRAYING MACHINE

Initially frame is fabricated and tank is fitted on its front side. Then four wheels and handle are attached to it to make the system stable and horizontal. Then Pump is attached to its frame at certain height and according to length if piston then cam mechanism is adjusted to make its proper alignment. Now fifth wheel is freely located on frame with help of its handle. Then transmission chain is fitted on it so that power from free fifth wheel gets transferred to cam mechanism which in turns transferred to pump. Now intake to pump is taken from storage tank through pipe with filter. And output of this pump is given to nozzles through pipe mechanism through clutch system as shown in figure1 and figure 2.

Fig -1: Developed project

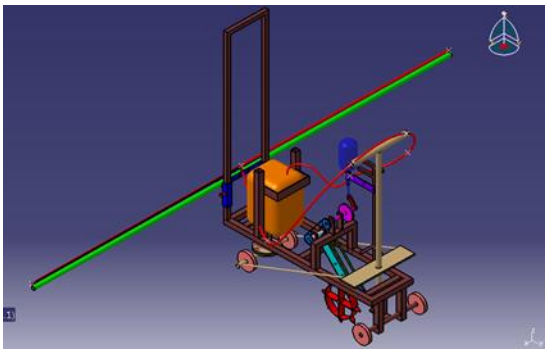
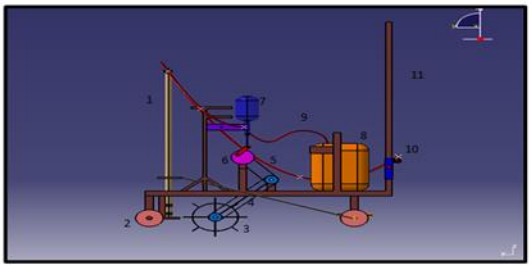


Fig -2: CAD model of project

3. WORKING OF THIS PESTICIDE SPRAYING MACHINE

Working of this model can be explained with help of figure 3.

When person will push this machine through handle (1) then the whole machine will move in forward direction using four wheels (2) As the machine moves in forward direction, fifth free toothed wheel will also move with the machine. As this toothed wheel (3) will move the tooth's on it will engage with land and hence will create power on it. This rotation of wheel transfer this power to reciprocating pump (7) through two chain drives (4) and (5) and then through cam mechanism (6). As toothed wheel will rotate two chain drives will rotate which will rotate cam mechanism which generates reciprocating motion to piston of pump. As pump works it will suck water pesticide mixture from storage tank (8) through pipes (9) and this will pressurize in pump. When needed this pesticide is passed through Flat Pan Nozzles attached to boom (10). Height of this boom with nozzle can be adjusted by adjusting height of boom on boom support (11).



1: Handle, 2: Wheels, 3: Toothed Wheel, 4: Chain Drive 1,
5: Chain Drive 2, 6: Cam Mechanism, 7: Reciprocating Pump,
8: Storage Tank, 9: Pipes, 10: Boom with Nozzles, 11: Supporting Rod for Boom adjustment

Fig -3: CAD model description

4. DESIGN OF DRIVING MECHANISM FOR THIS PESTICIDE SPRAYING MACHINE

Important design parameter in this project is design of driving mechanism. This design includes estimation of drive force for machine in order to check whether drive force required to push the machine is in permissible limit of an average human pushing force according to ergonomics. This can be explained as follows.

For calculation of demand drive force/ Total tractive force (TTE) of machine it is important to calculate a) force required to overcome rolling resistance of whole machine (RR), b) force to overcome gradient resistance of machine (GR), c) force to accelerate equipment to gain its maximum velocity for operation (FA), d) force to overcome resistance due to power generating fifth wheel (FB).

TTE [Kg] = RR [Kg] + GR [Kg] + FA [Kg] + FB [Kg]…….. (A)

a) Estimation of rolling resistance (RR)

RR [Kg] = GVW [Kg] x Crr [-]

Where:

RR = rolling resistance [Kg]

GVW = gross vehicle weight [Kg]

Crr = surface friction

Contact Surface	C_{rr}
Concrete (good / fair / poor)	.010 / .015 /.020
Asphalt (good / fair / poor)	.012 / .017 / .022
Wood (dry/dusty/wet)	.010 / .005 / .001
Snow (2 inch / 4 inch)	.025 / .037
Dirt (smooth / sandy)	.025 / .037
Mud (firm / medium / soft)	.037 / .090 / .150
Grass (firm / soft)	.055 / .075
Sand (firm / soft / dune)	.060 / .150 / .300

Fig -4: Table for surface friction between rubber wheels and contact surface

So,

RR [Kg] = GVW [Kg] x Crr [-]

= 70 x 0.09

Crr = Considering Medium Mud

RR [Kg] = 6.3 Kg…… (1)

a) Estimation of grade resistance (GR)

GR [Kg] = GVW [Kg] x sin (α)

Where:

GR = grade resistance [Kg]

GVW = gross vehicle weight [Kg]

α = maximum incline angle [degrees]= 10 degree (consideration)

So,

GR [Kg] = GVW [Kg] x sin (α)

= 70 x sin (10)

GR [Kg] = 12.15 Kg…… (2)

b) Estimation of acceleration force (FA)

FA [Kg] = GVW [Kg] x Vmax [m/s] / 9.8 [m/s^2] x ta [s]

Where:

FA = acceleration force [Kg]

GVW = gross vehicle weight [Kg]

Vmax = maximum speed [m/s]

ta = time required to achieve maximum speed [s]

Consider maximum velocity the machine achieved is 10m/s in 10 seconds.

So,

FA [Kg] = GVW [Kg] x Vmax [m/s] / 9.8 [m/s^2] x ta [s]

=70 x 0.1666 / 9.8 x 10

FA [Kg] = 0.119 Kg…… (3)

c) Estimation of force on toothed wheel (FB)

Toothed wheel is used to drive piston cylinder arrangement via transmission to generate pressure of 2.5 kg/cm^2 or 0.25 N/m^2 maximum pressure (P) (as calculated below). So the opposing force acting on human is to overcome forces acting on fifth wheel which is nothing but forces exerting on it from piston to the fifth wheel.

Force generating on fifth wheel is pressure force which is in compression state on piston to fifth wheel via cam mechanism and two chain transmissions.

To calculate force on wheel we have to calculate

i) Force on piston
ii) transmission losses in Cam mechanism and
iii) Losses in two chain drives.

I) to calculate force on piston:

Force (Fa) on piston is nothing but force on piston rod Di. We know that force acting on piston rod is Fa = ($\frac{\pi}{4}$) x Di^2 x P

= ($\frac{\pi}{4}$) x 38^2 x 0.25

= 283.52 N or 28.3 Kg…… (i)

II) To calculate force due to Piston cylinder assembly including friction losses in piston:

Consider total 1 percent of friction losses are there in piston cylinder assembly.

So these 1 percent friction losses are

= Total force in piston assembly x 1 percent loss

= 28.3 x 0.01

= 0.283 kg force will resist the action of piston.

Machine	Typical Efficiency
V-belt drives	95%
Timing belt drives	98%
Poly-V or ribbed belt drives	97%
Flat belt drives, leather or rubber	98%
Nylon core	98% to 99%
Variable speed, spring loaded, wide range	
V-belt drives	80% to 90%
Compound drive	75% to 90%
Cam-reaction drive	95%
Helical gear reducer	
Single-stage	98%
Two-stage	96%
Worm gear reducer	
10:1 ratio	86%
25:1 ratio	82%
60:1 ratio	66%
Roller chain	98%
Leadscrew, 60 deg helix angle	65% to 85%
Flexible coupling, shear-type	99%+

Fig -5: Table of standard transmission losses considered in industries

So total force acting due to piston cylinder assembly is

Fb = Total force action on piston (Fa) + Force due to friction in assembly

= 28.3 + 0.283

Fb = 28.583 Kg…… (ii)

III) To calculate force due to transmission losses due to cam mechanism.

Further losses added due to cam mechanism is nothing but cam transmission force loss added to total force on piston assembly. From table 4.2 as above total transmission loss considered due to cam mechanism is 5 percent.

So total force Fc acting including transmission losses due to cam mechanism is

Fc= Fb + Transmission losses due to cam mechanism

= Fb + (Fb x 5%)

= Fb + (Fb x$\frac{5}{100}$)

= 28.583 + (28.583 x $\frac{5}{100}$)

Fc =30.00 kg…… (iii)

IV) To calculate force due to transmission losses due to two chain drives.

So total force Fd acting due first chain drive mechanism transmission losses is

Fd= Fc + Transmission losses due to cam mechanism

= Fc + (Fc x 2%)

= Fc + (Fc x$\frac{2}{100}$)

= 30.00 + (30.00 x $\frac{2}{100}$)

Fd =30.60 kg…… (iv)

So total force Fe acting due first chain drive mechanism transmission losses is

Fe= Fd + Transmission losses due first chain drive mechanism

= Fd + (Fd x 2%)

= Fd + (Fd x$\frac{2}{100}$)

= 30.60 + (30.60 x $\frac{2}{100}$)

Fe =31.21 kg…… (v)

So total force acting due to fifth wheel assembly including all transmission losses is given by

FB [Kg] = 31.21 Kg…… (4)

So, Total Tractive force TTE is

TTE [Kg] = RR [Kg] + GR [Kg] + FA [Kg] + FB [Kg]

= 6.3 + 12.15 + 0.119 + 31.21

TTE [Kg] = 49.77 Kg

= 49.77 x 9.81 N

TTE [N] = 488.33 N

Now according to Waldevar Kanwowski and William S. Marros in e-book "The Occupational Ergonomics Handbook" an average person can exert a maximum pushing force of 640 N.

And according to our calculation total pushing force considering all factors is calculated as 488.33N.

As 488.33N < 640N

So, an average person can exert a maximum pushing force > Total pushing force for this machine.

So our machine is easily functional considering all ergonomic factors. So our design is safe.

5. HIGHLIGHTED IMPORTANT ASPECTS DEVELOPED IN THIS PROJECT

1) This machine sprays and cover area of 10 feet horizontally and 6 feet vertically and can be adjusted in this range,
2) Nozzles can also be adjusted according to pattern of crops,
3) Machine takes around 7 hours to complete spraying of 1 hector of land,
4) And it sprays mixture of around 242 liters pesticide-water uniformly to cover 1 hector of land,
5) 12 times refilling of mixture is needed to cover 1 hector of land and it takes 35 minutes to empty 1 full tank of pesticide mixture,
6) According to structure of land it has self-adjustable 5th power driving wheel,
7) End to end wheel base of project is adjustable in range of 14-16 inches,
8) Well balanced and hazard free machine,
9) No fuel requirement,
10) Capacity of tank can be adjusted from 20-40 liters and hence performance can be increased.

CONCLUSION

It is found that the existing pesticide spraying machines use petrol and diesel to run. It can cause pollution and further the vibration produced in the machine cause noise pollution, while portable hand held machine may cause health problems for person as he directly comes in contact with insecticide. In advent of avoiding such problems enlisted in first point, an adjustable manually push operated pesticide

spraying pump seems an alternative concept. Comparison between the existing machineries and present machine shows that an adjustable manually push operated pesticide spraying pump can work very efficiently with respect to covering area, time and cost of spraying process. Also it seems economical. The demand force required for spraying shows that this machine can be used efficiently in all types of farms. This machine is adjustable in height as well as it area of spraying can be adjusted depending on pattern of plants which makes this machine unique in nature. Since human energy is needed to drive the machine, it may provide jobs to the persons for uneducated person who is need for such jobs.

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