Design and Manufacturing of Pesticide Spraying Machine

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Abstract - *As India is agriculture based country and 70% people do farming and related work. Agriculture is required to be boomed to enhance the Gross Domestic Product (GDP) of the country by improving the productivity. The population of the world is increasing rapidly. In order to fulfill their diet needs the production of food must be increased, but this must come at a cost affordable to everyone. Mechanization of agriculture enables conservation of inputs by precision in ensuring better distribution, reducing quantity required for better response or prevention of losses or waste of inputs applied. Mechanization reduces unit costs of production through higher productivity levels and the input conservation. The all agriculture equipment's often are hardly modernized due to its low productivity. In India farming is done by traditional ways, besides that there has been large development of industrial and service sector as compared to that of agriculture sector. The spraying of pesticides and insecticides is traditionally done by farm worker carrying backpack type sprayer which requires more human effort. Giving attention to these important problems an attempt is made to develop an equipment which will be beneficial to the farmer for the spraying operations. This equipment is easy to use and operate. It makes use reciprocating pump that creates the required pressure for the spraying action. This multifunction device will come in handy that can be put to use in different spraying stages of farming as per process requirement. So we have designed a pesticide spraying machine which will not only increase productivity but also will reduce the effort of the farmers. The machine will save the time of the farmer as well as efficiency in spraying. This model carries 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.*

***Key Words*: GDP, Pest Control, Pesticide Spraying Machine**

1. INTRODUCTION

In order to reduce the harm to the environment and people the research and development of plant protecting machine focus on improving the mechanical work efficiency and the effective availability of pesticide. One of the most common forms of pesticides application, especially in conventional agriculture, is the use of mechanical sprayers. Hydraulic sprayers consist of a tank, a pump, a lance (for single nozzles) or boom, and a nozzle (or multiple nozzles). Sprayers convert a pesticide formulation, of one containing a mixture of water (or another liquid chemical carrier, such as fertilizer) and chemical, into droplets, which can be large rain-type drops or tiny almost invisible particles. This conversion is accomplished by forcing the spray mixture through a spray nozzle under pressure. The size of droplets can be altered through the use of different nozzle sizes, or by altering the pressure under which it is forced, or a combination of both. Large droplets have the advantage of being less susceptible to spray drift, but require more water per unit of land covered. Due to static electricity, small droplets are able to maximize contact with a target organism, but very still conditions are required. Sprayers are commonly used on farms to spray pesticides, herbicides, fungicides, and defoliants as a means of crop quality control.

1.1 Various Spraying Techniques

Some types of spraying techniques are as follows:-

1) Low pressure sprayer

(a) Tractor mounted

(b) High clearance sprayer

(c) Trailer-mounted Sprayers

(d) Truck mounted sprayers

2) High pressure sprayer

3) Air carrier sprayer

4) Fogger (Mist blowers)

5) Hand operated sprayer

6) Motorcycle Driven Multi-Purpose Farming Devices

Motorcycle Driven Multi-Purpose Farming Devices

This motor cycle driven plough can be used to carry out various farming operations like furrow opening, sowing, inter-culturing and spraying operations.

A] Aerial Sprayer

Aerial sprayer is another type of spraying it is beneficial for the farmers having large Farms. This technique by farmers is not affordable to farmers having small and medium farms. In aerial spraying the spraying is done with the help of small helicopter controlled by remote. On that sprayer is attached having Multiple nozzles and sprayed it on the farm from some altitude.

B] Backpack Sprayer

The tank in this sprayer holds about four gallons of material. A hand operated pump pressurizes the spray material as the operator walks along, and the wand with nozzle directs the spray to the target. It use is limited to small areas that can be reached from a walkway.

C) Truck-mounted Sprayers

This design consists of a skid-mounted sprayer, powered by an auxiliary engine, placed in a pickup or flatbed truck. Flotation tires are included on larger units to aid the sprayer's operation in wet conditions. These large models, including tanks that hold up to 2,500 gallons (9,463 L) and booms up to 60 feet (18.3 m) long, are most useful on expansive areas, or special applications.

D] High pressure sprayer

High-pressure application of chemicals is employed when spray needs to be driven through thick brush or tall trees.

These sprayers, heavier and more expensive than low-pressure models, are able to operate under working pressures as high as 1,000 pounds per square inch (6,895 kPa). Aside from these differences, they are also hydraulically operated and consist of the same basic parts as low-pressure versions; they can be applied to the same tasks when outfitted with a boom.

NEED FOR PROJECT

The objective of building this machine is to eliminate the physical fatigue and the health hazards caused by esticides. Following drawbacks of various spraying techniques shows the need of our project.

1] In the backpack spraying / solar operated sprayer the labor has to carry all the weight of the pesticides filled tank which causes fatigue to labor and hence reduces the human capacity.

2] The engine operated spraying equipment needs fuel for its running and proper operation which increase its operational cost and also its gives the back pain due to vibration problem.

3] In the aerial spraying wastage of fertilizer and some crops are not totally covered and also not suitable for small farms.

4] During spraying after sometime hand muscles starts to pain and thus proper pressure is not maintained. So it affects the droplet pressure.

5] When using fuel operated vehicles the exhaust gases liberated from the Silencer or muffler produces a harmful effort over the crops.

2. STATUS OF AGRICULTURE IN INDIA

India is predominantly an agricultural based country with approximately 75% of population of India is very much dependent on farming either directly or indirectly. The farmers have been using the same methods and equipment for ages for example the seed sowing, spraying, weeding etc. operations are carried out by same techniques. There is need for development of an effective spraying machine for increasing productivity levels. Most of the late developing countries of Asia have the problem of higher population and low levels of land productivity as of compared to the developed nations. One the main reasons for lower productivity is insufficient power availability for the farms and very low levels of farm mechanization. This is especially true for India.

DESIGN CALCULATIONS:

On the basis of assumptions and requirements

Drive Requirements

Driving Technique: Shaft through PTO

Rotational speed of the driven and driving machine

PTO 540 rpm

Pump 1450 rpm Power capability Pump 2 HP

We need to find required drive center distance and shaft diameter

Design Power

Service factor, (from tables - appendix 1) for medium duty under 10hrs/day = 1.3

Design Power =1.3x1.49kw = 1.937KW

Belt Pitch

With the reference of pitch selection chart intersection of

1450 rev/min and 1.937 KW to be within the capability of

8 mm pitch. (Appendix 3) Speed ratio: 1450/540= 2.71:1

From tables (appendix 2)

Number of grooves on

Driving pulley = 30

Driven pulley = 80

Centre distance = 576 mm

$$\theta_d = \pi - 2 \sin -1 \frac{D-d}{2C}$$

$$\theta_d = \pi - 2 \sin -1 \frac{0.18197 - 0.08016}{2 \times 0.576}$$

$= 170^o$

$= 3$ rad

$$\theta_D = \pi + 2 \sin -1 \frac{D-d}{2C}$$

$$\theta_D = \pi + 2 \sin -1 \frac{0.18197 - 0.08016}{2 \times 0.576}$$

$= 190^o$

$= 3.928$ rad

Belt Length

$L = \sqrt{4C^2 - (D-d)^2}$

$+\frac{1}{2}(D\theta_D + d\theta_d)$

$L = \sqrt{4 \times 0.576^2 - (0.18197 - 0.08016)^2}$

$\frac{1}{2}(0.18197 \times 3.319 + 0.08016 \times 2.965)$

$\therefore T = 5 \times 10^6 A\ Mpa$

Tension on the belt on the tight side, T= T- T_C

T_t= 4.759AMpa

Tension in the lower belt,

$L = 1.568m$

The standard belt length available is 1600mm. Power rating and belt width

Power rating for a 30 groove shows a value of 8.89 KW at

1450 rev/min for a 20 mm wide belt

Belt length factor for a 1600 mm belt = 0.90

Belt length factor × the table rating for 30 grooves gives

=0.9x8.89=8.001KW

Required Belt width factor = $\frac{Design\ Power}{Lenght\ corrected\ power\ rating}$

=1.937/8.001

= 0.2421

Next Larger standard width factor for 0.2421, we use 1.00

Therefore belt width = 20mm (from appendix 3) Mass of one belt is given by,

$m = A \times L \times \rho$

Taking density, $\rho = 1200\, {}^{kg}/_{m^3}$ And $2\beta = 40$

(from Shigleys Table 17-9)

$m = 1200 \times 1.6A = 1920A$

Centrifugal tension in the belt is given by, $T_c = mv^2$ Maximum tension in the belt,

$T_c = 1920A \times 125.44 = 240844.8A$

The allowable stress, is 5.0 MPa

$T = \sigma \times A$

$$\frac{T_t}{T_s} = e^{us\alpha} = 5$$

$$T_s = \frac{4.759 \times 10^6}{5} = 951831.04A$$

Power transmitted

$$= 11000 = P = (T_t - T_s)\,V$$

$$11000 = (4.759 \times 106\,A - 951831.04A) \times 11.2)$$

$$A = 258mm^2$$

Shaft size:

It was selected from the information are included in table

30 -8M-30

pitch diameter - 81.49,

Outside diameter- 80.16

Pulley type – 2F

Bush number 1615

80-8m- 30 pitch diameter - 203.72, Outside diameter- 181.97

Pulley type – 9

Bush number 2517

The 30 -8M-30 pulley uses a 1615 Taper lock bush. Maximum bore 42

The 80-8m- 30 pulley uses a 2617 Taper lock bush. Maximum bore 60

Final drive specification;

PTO –shaft pulley 80-8m- 30 HTD pulley

Pump pulley 30 -8M-30 HTD pulley

Belt 8 Max pitch – Belt length –

1600mm

Width	20mm
Centre distance	576mm
Groove angle	40

Length	1600rpm
Coefficient of friction	0.2
Allowable tensile stress	5Mpa

Shaft

Basic stress equation,

$$\sigma_b = \frac{32M}{\pi d_0^3(1-k^4)}$$

Where; M = Bending moment at the point of force do = Outer diameter

k = Ratio of inner to outer diameter of shaft.

K=0 for solid shaft like our case. Thus our equation reduces to

$$\sigma_b = \frac{32M}{\pi d_0^3}$$

$$\sigma_b = \frac{4\alpha F}{\pi d_0^3(1-k^4)}$$

Where; F = Axial force (tensile and compressive)

α = column action factor

Design of the shaft mostly uses maximum shear stress theory. It states that a machine member fails when the maximum shear stress at a point exceeds the maximum allowable shear stress for the shaft material.

$$\therefore \tau_{max} = \tau_{allowable} = \sqrt{(\frac{\sigma_x}{2})^2 + t_{xy}^2}$$

ASME design code

The shafts are normally acted upon by gradual and sudden loads. Hence the equation is modified in ASME code by suitable load factors.

The shaft equation considering the above thus can be simplified to

$$\sigma_b = \frac{32M_{eq}}{\pi d^3}$$

Where;

$$M_{eq} = \frac{1}{2}\left[M_b + \sqrt{{M_b}^2 + M_t^2}\right]$$

Material used for the shaft is 4140 Annealed Cold Roll steel whose Sut is 650 Mpa and Syt is 450 Mpa

Tractor power for a required of the PTO at 540 rpm is

11Kw

$$M_t = \frac{60 \times Kw \times 10^6}{2\pi n}$$

$$M_t = \frac{60 \times 11 \times 10^6}{2\pi \times 540}$$

$$= 194522.708/mm^2$$

Calculating the reaction on the pulley,

$$Mt = (Tt - Ts) \times Radius\ of\ belt\ pulley$$

$$Mt = (Tt - Ts) \times 40.08 = 194522.708 N/mm^2$$

$$Tt - Ts = 4853.36$$

But,

$$Tt = 5Ts$$

$$\therefore T_s = 1213.13N$$

$$\therefore T_t = 6066.7N$$

$$Net\ vertical\ force = 7279.81N$$

For this design there is a key way hence permissible shear stress is reduced by 25 %.

$$\tau_d = \frac{16}{\pi d^3}[(k_b M_b)^2 + (k_t M_t)^2]$$

Where; K_b = combined shock and fatigue factor applied to bending moment

It is equal to 1.5 for gradually applied loading

K_t =combined shock and fatigue applied to torsional moment.

K_t is equal to 1 for gradually applied loading

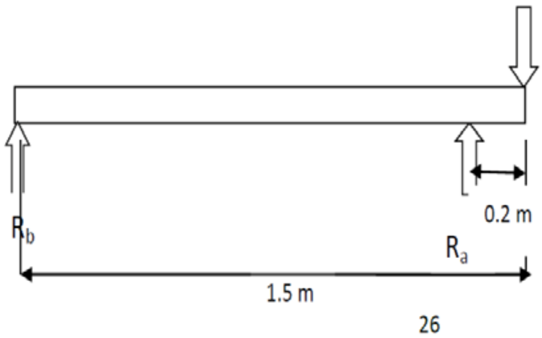
Thus

$$\tau_d = \frac{16}{\pi d^3}[(1.5M_b)^2 + (M_t)^2]$$

The value for for τ_d 4140 Annealed cold roll steel shaft material is 400Mpa.

Factoring the reduction due to key ways this value reduces

by 25% thus becomes 300Mpa. Calculating for M_b



The bending moments, Mb

$$1.5Rb = 7279.83 \times 0.2$$

$$Rb = 1455.97\ N$$

$$Ra + Rb = 7219.83N$$

$$Ra = 5823.86N$$

Bending moment,

=1.5×1455.97

=2183.95Nm

From

$$M_{eq} = \frac{1}{2}\left[M_b + \sqrt{{M_b}^2 + M_t^2}\right]$$

$$M_{eq} = \frac{1}{2}(2183.95 + \sqrt{2183.95 + 194522.708^2})$$

$$M_{eq} = 98361.66$$

From,

$$\sigma_b = \frac{32M}{\pi d^3}$$

$$320 \times 10^6 = \frac{32 \times 98361.66}{\pi d^3}$$

$$\therefore d = 0.0975m$$

Diameter of the shaft will be 10 cm

Pump

The pump used is a centrifugal pump of 1450rpm and 2 horsepower.

From appendix 5, a pump of 1450 rpm has a discharge of;

66m^3/h=0.01833 m^3/s=18.33ltrs/s

Delivery from nozzles

Assuming nozzle orifice diameter of 2 mm. Using continuity equation

From the graph for PVC pipe schedule 120, a pipe with the following dimension was chosen.

Nominal pipe size (inches) = 1.5

Outside diameter, inches = 1.9″ = 48.26

Internal diameter, inches = 1.423″ =36.1442mm Wall thickness, Inches = 0.225″ = 5.715mm Maximum working pressure, = PSI 540= 37.23 bar

Q1=Q2, this implies that Q=V1A1=V2A2.

The discharge from the pump is 18.33 litres/min [from graph; appendix 5] of internal diameter 36.1442mm [pvc schedule 120]

So,

$$0.01899 = V_2 \times \pi \times (\frac{36.1442}{2} \times 10^{-3})^2$$

$$V_2 = 17.86m/s$$

This delivery pipe takes the chemical to control valve from which the delivery system is subdivided into three pipes of one inch each which deliver to nozzles.

Q=V3A3

$$0.01899 = V_3 \times \pi \times (\frac{22.6314}{2} \times 10^{-3}) \times 3^2$$

$$V_2 = 15.189 m/s$$

Using continuity equation

V3A3=V4A4

There are 4 nozzles in each delivery pipe

$$\pi \times (\frac{22.6314}{2} \times 10^{-3})^2 \times 15.189 = \pi \times (1 \times 10^{-3})^2 \times V_4 \times 4$$

$$V_4 = 42.62 m/s$$

$$Discharge\ from\ orifice = area \times velocity$$

$$= \pi \times (1 \times 10^{-3})^2 \times 42.62$$

$$= 1.3409 \times 10^{-4}$$

$$= 8.045\ L/min$$

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3. CONCLUSIONS

1) The motive behind developing this equipment is to create mechanizations which will help to minimize effort of farming.

2) It is suitable for the spraying at minimum costs for the farmers so that he can afford it, of the many products available.

3) It is most important to select the most. Efficient and easy type for your particular needs, whether if it is for applying insecticide fungicides, weed killer, liquid fertilizers or wettings agents. For example, lawn sprayers are made especially for the applications of liquids material to the lawn area.

4) So considering the above points related to spraying the project work is focused upon to design and to fabricate such equipment which will be able to perform spraying operation more efficiently and also will result in low cost.

5) Flow rate is increased by 2.5 times the manually operated sprayer.

6) Area sprayed per hour has increased by 2.6 times of the manually operated sprayer and 1.5 times the knapsack power sprayer

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