International Journal of Modern Engineering Research (IJMER)
www.ijmer.com Vol.3, Issue.2, March-April. 2013 pp-864-868 ISSN: 2249-6645

Development of Multinozzle Pesticides Sprayer Pump

Sandeep H. Poratkar, [1] Dhanraj R. Raut[2]
[1]Mechanical Engineeringt, Tulsiramji Gaikwad Patil College of Engg & Technology, India
[2]Department of Mechanical Engineering, Uumrer Polytechnic, Umrer

Abstract: *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. But this sprayer has certain limitations like it cannot maintain required pressure; it lead to problem of back pain. However this equipment can also lead to misapplication of chemicals and ineffective control of target pest which leads to loss of pesticides due to dribbling or drift during application. This phenomenon not only adds to cost of production but also cause environmental pollution and imbalance in natural echo system. This paper suggests a model of manually operated 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.*

Keywords: *Back pain, constant flow valves, drift, multinozzle pesticides sprayer pump, small; marginal; medium farmer.*

I. Introduction

Agriculture plays a vital role in Indian economy. Around 65% of population in the state is depending on agriculture. Although its contribution to GDP is now around one sixth, it provides 56% of Indian work force [10]. Table 1 shows that share of marginal and small farmer is around 81% and land operated is 44 % in 1960-61. As far as Indian scenario is concerned, more than 75 percent farmers are belonging to small and marginal land carrying and cotton is alone which provide about 80 % employment to Indian workforce. So any improvement in the productivity related task help to increase Indian farmer's status and economy. The current backpack sprayer has lot of limitation and it required more energy to operate. The percentage distribution of farm holding land for marginal farmers is 39.1 percentage, for small farmers 22.6 percentage, for small and marginal farmers 61.7 percentage, for semi-medium farmers 19.8 percentage, for medium farmers 14 percentage and for large farmers 4.5 percentage in year 1960-61.Table 1 clearly explain that the maximum percentage of farm distribution belonged to small and marginal category.

Table I: Percentage distribution of farm holding and operated area for various farmers

	Percentage distribution of farm holding				Percentage distribution of Operated Area			
Land Class	1960-61	1981-82	1991-92	2002-03	1960-61	1981-82	1991-92	2002-03
Marginal	39.1	45.8	56	62.8	6.9	11.5	15.6	22.6
Small	22.6	22.4	19.3	17.8	12.3	16.6	18.7	20.9
Small & Marginal	61.7	68.2	75.3	80.6	19.2	28.1	34.3	43.5
Semi-medium	19.8	17.7	14.2	12	20.7	23.6	24.1	22.5
Medium	14	11.1	8.6	6.1	31.2	30.1	26.4	22.2
Large	4.5	3.1	1.9	1.3	29	18.2	15.2	11.8
Total	100	100	100	100	100	100	100	100

Fig I Percentage-wise Land distribution from 1960 to 2003

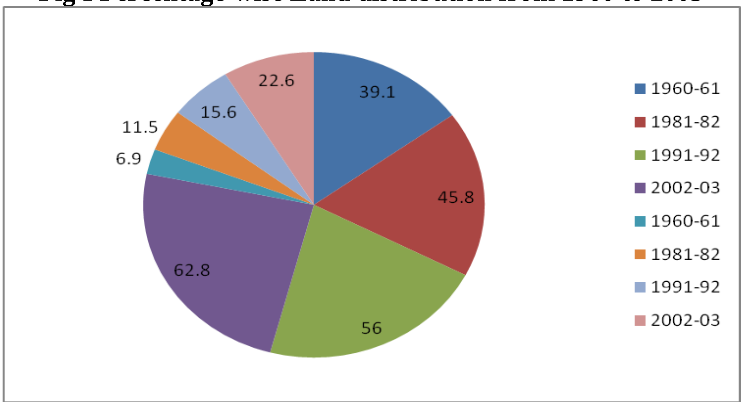


Fig I shows that percentage of the marginal, small and semi medium farmers is about 92.15 %, which states that growth of these farmers require advanced equipment which will work faster than existing one.

II. DESIGN REQUIREMENT

2.1 Drawbacks in 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[1].Also, the backpack sprayer cant maintain pressure, results in drifts/dribbling[9].Developing adequate pressure is laborious and time consuming.[13].Pumping to operating pressure is also time consuming[6]. 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.

2.2 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[5].This sprayer has a wide limitations and thus farmers can use the other sprayer also like bullock driven sprayer pump and tractor mounted sprayer. Cost of bullock driven is about Rs 28000/-[7]. 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

Table II:-Existing high features high cost sprayer

S.N.	Type of sprayer pump	No. of workers required for spraying	Area for which sprayer is used generally	Time required for spraying	Cost
1	Bullock Driven	2	More than manually operated	Less than manually operated	More than manually operated Rs 28000/-
25	Tractor Operated	1	More than other two	Less than above two	More than other two Rs 6.00 lacks to 7.00 lacks

2.3 Distances (horizontal & Vertical) and height of crop:

Table III:-No. of crops on which spraying is done and their horizontal, vertical distances and maximum height

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

III. Development of Model

Fig II CAD model of manually operated multi-nozzle pesticides sprayer pump

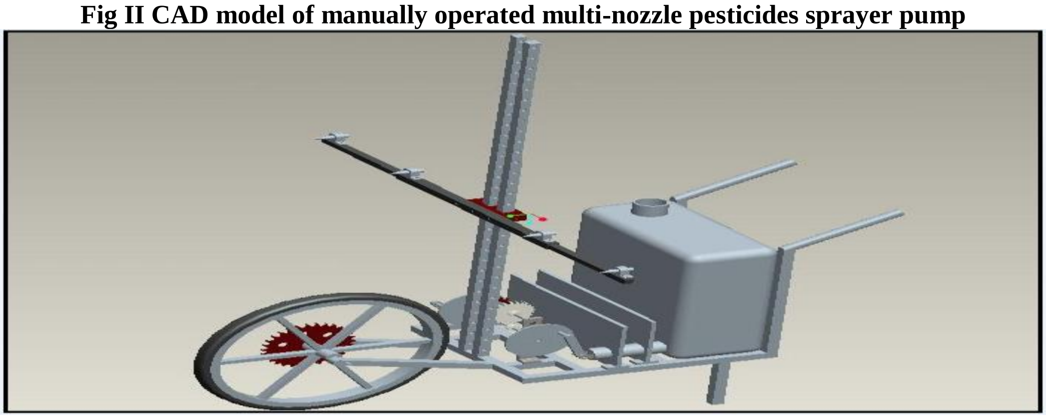
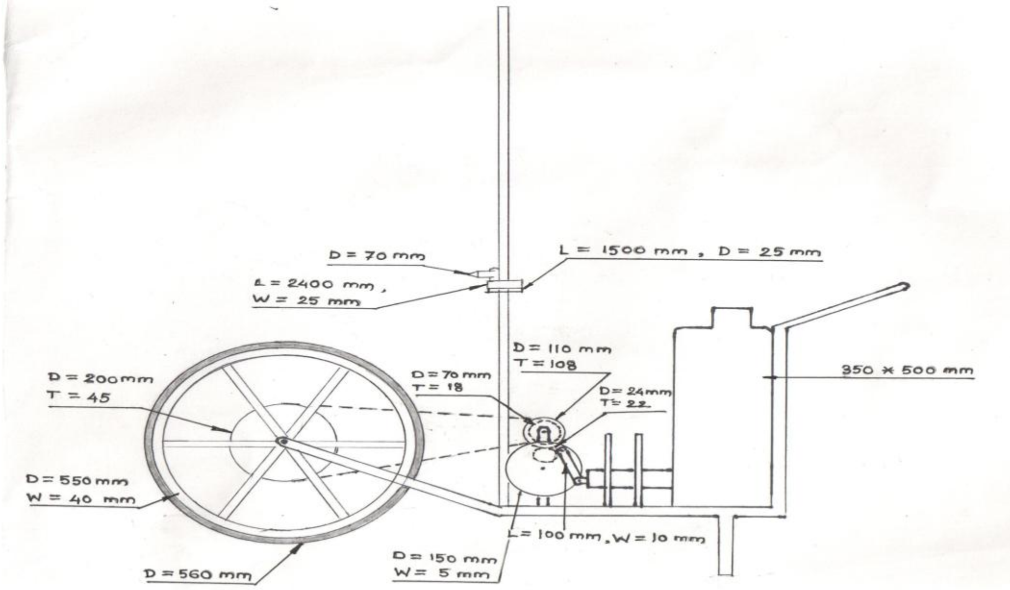


Fig III Side View of Manually operated multi-nozzle pesticides sprayer pump.



IV. Working

The working of this manually operated multi nozzle pesticides sprayer pump is based on the principles of motion transmission due to chain and sprocket arrangement and plunger cylinder arrangement. The operator first stand behind the trolley. He will grab the handle and lift it and push the trolley forward. As trolley move forward, the wheel rotates in counterclockwise direction. As sprocket is mounted on same shaft of wheel, it also rotates in counter clockwise direction. This motion is transferred to freewheel via chain drive arrangement. The freewheel, thus, also starts rotating in counterclockwise direction. As freewheel and big spur gear are mounted on same shaft, it also start rotating in anticlockwise direction. This will rotate small spur gear in clockwise direction as it is externally meshed with it. Due to this, the disc start rotating which give motion to link as it is fixed on the disc. The plunger is attached to disc via link. The plunger got motion due to this which stimulates pesticides to come outside via six nozzles.

Table IV Selection of components with their material specifications

Sr. No	Name of component	Dimensions	Material used	Material specification
1.	Frame	350*900 mm.	M.S.	Cheap, durable, good strenght
2.	Tank	350*500 mm.	plastic	Light in weight , dureble
3.	Nozzle	D = 70 mm.	Plastic	For P upto 3 bar from traditional sprayer..... wrtlr
4.	Nozzle bar	L = 2400 mm., W = 25 mm.	Steel	Dureble , light in weight
5.	Adjuster bar	L = 1500 mm., D = 25 mm.	Steel	Dureble , light in weight
6.	Link	L= 100 mm., W=10 mm.	M.S.	Cheap, durable,good strenght
7.	Disc	D = 150 mm.,w =5 mm.	M.S.	Cheap, durable,good strenght
8.	Wheel	D =550 mm., W=40 mm.	Steel	Cheap, durable,good strenght
9.	Tyre	D=560 mm.	Rubber	For friction purpose
10.	Sprocket	D=200 mm.,T = 45, m= 4.45	Steel	Adopted from Hero Cycles Specification for transmittinf force upto 50 N, chip, durable,
11.	Free wheel	D=70 mm.T= 18, m= 3.88	Steel	
12.	Spur gear big	D=110 mm., T=108, m=1.01	Nylon	For parallel shaft power transmission and have high velocity ration
13.	Spur gear small	D=24 mm.,T=22, m=1.09	M.S with hardened upto 60 BHN	
14.	Shaft	L=200 mm.,D=18 mm.	M.S. bright bar	Shaft is taken with respect to inner diameter of freewheel of Hero cycle
15.	Shaft	L=230 mm.	M.S. bright bar	

V. Design Calculations

Sprocket: No. of Teeth = T1=45, Diameter = D1= 200 mm, Pitch = 12.5 mm
Freewheel: No. of Teeth = T2=18, Diameter = D2= 70 mm, Pitch = 12.5 mm
Spur gear big:No. of Teeth = T3=45, Diameter = D3= 110 mm
Spur gear small: No. of Teeth = T4=22, Diameter = D4= 24 mm

5.1Chain and sprocket

Gross weight of system = 25 kg=25*9.81=245.25 i.e. 246 N
Radius of rear wheel = r_w=350 mm
Designed acceleration = t_a=10 sec
Coefficient of rolling resistance = Crr=0.017
Gradient= 0^0
Total tractive force= sum of Rolling resistance, Gradient resistance and Accelerating force
Rolling resistance=weight* Crr =246*.017=4.17 N
Gradient Resistance=Weight * sin θ = 246*0=0
Accelerating force= (weight*V)/(g*t_a)=(246*2)/(9.81*10) = 5N
Total Tractive Force = 4.17+0+5=9.17 N
Thus,
Force required to drive a system = 9.17 N
Now,
Pulling force transferred to handle = F_R = ((F*R_C* R2) / (R_W* R1))
Where,
F=Force transmitted to wheel=9.17N
Rc=Distance between Pulling Centre to sprocket centre=520mm
R2=Radius of Rear Sprocket=200/2=100mm
R1=Radius of freewheel=70/2=35 mm
Therefore,
F_R= ((9.17*350*100) / (520*35)) = = 17.63 N is a Pulling Force
Thus,
Torque = F_R* distance =17.63*.2=3.526 N-m
Thus,
Power, P_R= (2 * Pi* N *T)/60= (2*3.142*2*3.526)/60=0.7384 watts.
Design Power=P_d= P_R*K_l=0.7384*1.2=0.88603 watts K_l=1.2 from pn 150 TN XIV1 s.n.1
(D1* N1 / 60) = (D2*N2 / 60)
(200/70)= (N2/2) i.e. N2=5.82=6 rpm
Torque Available at freewheel is (T1/T2) = (D1/D2) i.e.T2=T1/(D1/D2)=1.2341 N-m
F_R = ((F*R_C* R2) / (R_W* R1))
Power available at freewheel, P2= (P1*90%) = 0.7384*0.9=0.66456 watts
As Freewheel and Sprocket Mounted on Same shaft
T2=T3=1.2341 N-m and P2=P3=0.6656 Watts; N2=N3=6 rpm
As Gear 3 and Gear 4 are externally meshed,
(D4/D3) = (N3/N4) i.e. (24/110)/(6/N4) i.e. N4=28rpm

5.2 Calculation of Spur gear/Design of Spur gear

Tg = T3 = 108
Tp=T4=22
N2=N3=6 rpm
Np=N4=28 rpm

1. Pitch line velocity = Vp = (Pi*Dp*Np)/60000 =(Pi*264*28)/60000=0.387 m/s where, Dp=No. of teeth * module=22*12=264
2. Design Power= Pd=Pr*Kl =(0.7384*1.25)=0.88603watts where, Kl=1.25 by Table no. XVI-2/P.N.166 of DDB
3. Velocity factor= Cv=0.885 T.N.XVI-3/pn166
4. Basic Stress for gears=So=175 Mpa T.N.XVI10
5. Modified Lewis Form Factor= Y=0.39- (2.16/Tp) = 0.39-(2.16/22)=0.291 TN XVI5
6. Bending Strength= F_B=So*Cv*b*Y*m = 175*0.885*264*0.2918*12=1431.6 N
7. Dynamic load F_d=Ft+((21 Vp(c*e*b+Ft)) / (21 Vp(c*e*b+Ft)$^{1/2}$))) C=12300 TNXVI4

E=0.097mm for m=12 mm,
B=8m=8*12=96
Vp =0.387
Thus, Fd=2688 N

8. Limiting Wear Strength Fw= Dp*b*K*Q TN XIV1

Dp=364
b=8*12=96,
K=302 i.e.load stress factor pnXVI-6
Q = Size factor = 2 tg/(tg+tp) for externally meshing gear..
= (2*108)/(108+22)
=1.6615

Thus, Fw=12717.1 N
Check Fw Limiting Wear Strength > Dynamic loadF_d,
As (Fw=) 12717.1 N > (Fd=) 2688 N Thus Design is safe

VI. Conclusion

1. The suggested model has removed the problem of back pain, since there is no need to carry the tank (pesticides tank) on the back.
2. As suggested model has more number of nozzles which will cover maximum area of spraying in minimum time & at maximum rate.
3. 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.
4. Proper adjustment facility in the model with respect to crop helps to avoid excessive use of pesticides which result into less pollution.
5. Imported hollow cone nozzles should be used in the field for better performance.
6. Muscular problems are removed an there is no need to operate the lever.
7. This alone pump can used for multiple crops

References

[1] Application technology: Problems and opportunities with Knapsack sprayer, Including the cf valves or Constant Flow Valves.-David McAuliffe and Vanessa P. Gray
[2] Journal of arboriculture weed control in landscape plantings1 by J.F. ahrens april 1981 vol. 7, no. 4.
[3] Backpack Sprayer-Modified for small farm Crop Protection-Rutgers Snyder Research & Extension Farm Staff–Edited by John Grande and Jack Rabin.
[4] To Spray or Not to Spray: Pesticides, Banana Exports, and Food Safety John S. Wilsona Tsunehiro Otsuki*,b a b Development Research Group (DECRG), World Bank, 1818 H Street NW, Washington, D.C. 20433, USA March 2002.
[5] Farmers understanding of pesticides safety labels and field spraying practices. By Oluyede Clifford Ajayi and Festus K. Akinnifesi_Scentific Research and Essay Vol (2), pp.204-210, June 2007 ISSN 1992-2248@2007 Academic Journals
[6] Wilcoz. M. 1969. A sprayer for application of small amounts of herbicides to flats. Weed Sci. 17:263-264
[7] Performance evaluation of bullock drawn sprayers for cotton crop-m. Veerangouda, k. V. Prakash, jag jiwan ram and g. Neelakantayya
[8] Designing, construction and evaluation of tractor-back sprayer with Variable Rate Technology (VRT) by using aerial maps information Mehrdad Fouj Lali1, Parviz Ahmadi Moghadam2 1 msc in Mechanics of Agricultural Machinery, Urmia University, Iran 2 Assistant Professor in Mechanics of Agricultural Machinery, Urmia University, Iran.
[9] Effect of the Constant Flow Valves on Performance of Pesticide Sprayer by A. R. Tahir, F .H .Khan, A. A. Khan 1560-8530/2003/05-1-49-52 International Journals of Agriculture and Biology
[10] Maharashtra Progressive Agriculture – A new Horizon –Confederation of Indian Industry
[11] Modification of a knapsack sprayer for more efficient use j. Founk
[12] Small farmers in India-Challenges and opportunities- S.Mahendra Dev-
[13] Modification of a Knapsack Sprayer for more efficient use- J.Founk Research Station, Agriculture Canada, Harrow, Ontario NOR.