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Fabrication of Portable Foot Operated Agricultural Fertilizers and Pesticides Spraying Pump

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***Abstract*—There are different types of cultivators in India namely small, marginal, medium and rich. Small scale farmer's use conventional manually lever operated knapsack sprayers because of the three reasons; it is user friendly equipment, ease of design and cost effective machine. But it cannot maintain required pressure; it also leads to lumbar pain. However this equipment can also lead to misapplication of chemicals and ineffective control of target pest. It leads to the loss of pesticides due to dribbling or drift during application.**

This process not only adds to cost but also hazardous to the environment and causes imbalance in natural eco system This paper suggests a proto type of foot operated pesticide spraying pump. It helps spraying at maximum rate in less time.

Key Words—Spray pump, Lumbar pain, foot operated, constant flow valves, medium farmer.

I. INTRODUCTION

India is a developing country. It has a rich land source which is the best suited for agriculture. Rural people, who constitute nearly 70 percent of population, are dependent on agriculture as a main occupation. It is very essential to develop methods for better agriculture. Technology can effectively alter the production rate by providing various modern agricultural implements which save man hour and money. It is also well known fact that India is characterized by low per capita income. Therefore it necessitates the technological people or the agricultural engineering who provide agricultural implements; which are most sophisticated and can be procured by the farmers at feasible rates.

Present day in agriculture the sprayers play an important role in spraying pesticides. Although sprayers varies like motorized, hand operated and in helicopter. The current idea on sprayer in our project is to utilize effectively, the weight of man which is wasted while moving to the field. In the conventional sprayer one has to use left hand or right hand or both the hands to give pressure. In this project an attempt is made to use the gravitational force (weight) of a person (farmer) which is wasted while walking in the field. So we made an energy saving device, which can also be used by a handless person.

Pumping mechanism fixed at the foot which will pump the air into the tank and through the control valves connects two set of sprayer handle to effect the spraying from both the hands to have more coverage of pesticide spraying area in less time.

II. LITERATURE SURVEY

Pesticides are the chemicals used to control the various diseases in crops. Farmers use various types of sprayers for pesticide spraying. Types of sprayers depend on the spraying methods. Basically there are four types of sprayers; Backpack (Knapsack) Sprayer, Machine mounted sprayer, Motorcycle Driven sprayer and aerial sprayer [1]. Pedal operated spraying pumps can also be used to reveal stress on upper or lower lumbar positions. The same machine can be operated continuously for more than two hours without being tired. [2]. Sandeep H. Poratkar, Dhanraj R. Raut have developed multi nozzle pesticides sprayer pump which is based upon principles of motion transmission due to chain and sprocket arrangement and plunger cylinder arrangement. This equipment developed mainly to get relief from back pain and muscular problems [3]. Recently there are many research works are going on sprayer pumps for the welfare of the farmers. Wheel driven sprayers have been developed in present scenario which aids human comfort while working. Multi- purpose spraying pumps are added advantages in this regard, which will run on mechanical power and consume less time when compared with hand operated pumps [4]. The difficulties are minimized by modifying the two stroke petrol engines. Direct current motor is operated by the electric energy by utilizing battery power. The pumping efficiency is increased by selecting the suitable type of nozzle spray patterns [5]. Vern Hofman and Elton Solseng Agricultural and Biosystems Engineering North Dakota State University has studied on the importance of avoiding the drift and dribbling by selecting the proper material for nozzle design [6]. A portable spraying pump is been developed by Shivaraj kumar and parameshawar Murthy which consists of wheel operating system by pedal which achieves the spraying [7].

III. CONSTRUCTION AND WORKING PRINCIPLE

This mechanism which is fitted on our foot will be activated when our kinetic force being applied on it, that is when we stamp our foot, this will be activated to push down the piston within the cylinder to pump in air to the tank. The foot shoes are riveted to the hinge which in turn holds the base plate pusher on which closes down the piston to pump out the air from the cylinder. The piston and cylinder construction is such a way that the air is sucked into the cylinder through the piston during the upward stroke through the spring mechanism and during the downward stroke the piston pushes the air from the cylinder through a non-return valve into the tank being shoulder held. The flow is controlled by control knob provided on the valve. The connection is through a T which joins both the foot pipes to the one pipe which connects to the tank. The tank is held on the back and the outlet is given at the top of the tank. From the tank the pipeline are connected to the sprayer jet hand held. The tank is buckled to the shoulder by the clamp.

A. Abbreviations and Acronyms

Gallons per Acre (GPA), Miles per Hour (MPH), Gallons per Minute (GPM), Sprayed width per nozzle (W), Output Per Minute (OPM) and Nozzle Flow Rate (NFR)

B. Parameters involved

1) Designing the piston pump which works on foot while stamping the ground, for both the foot.
2) Designing and fabricating the tank for shoulder holding and storing pesticide which can be carried Conveniently.
3) Connecting two set of sprayers with valves to hold in both the hands and effect spraying covering more area coverage instead of one sprayer.

C. Capacity of the device

The unit is used to spray the pesticide to the plants and the spraying is fast since the pressure is generated by natural walking and the amount of spray applied to an area will depend on the walking speed, pressure selected for spraying, and nozzle tip chosen. The tank capacity, total weight a person can sustain on shoulder is approximately 10kg, so the material taken into the tank is approximately 4 to 5 liters and with air pressure the tank capacity will be approximately 8 liters.

D. Power utilization

The mechanism of pumping works by the foot pressure while stamping on the ground, since it is done by normal walking on the ground without putting any extra effort so no extra power is required for activation, No power is used by the system.

E. The amount of spray applied to an area will depend on four variables

1. The walking speed
2. The amount of pressure applied.
3. The spray swath width
4. The nozzle tip chosen.

F. Design considerations

1) The swept volume of the air pump is to be calculated for the input air filling into the tank per stroke.
Diameter of the cylinder is 51.5 mm and the stroke length is 40 rnm—85 cc per stroke per cylinder so the total volume of air pumped is 170 cc per movement
2) The number of strokes required to attain the particular pressure and volume in the tank.
3) The spraying effected at the particular pressure using two number of jets
4) Tank volume and pressure withstanding capacity. (Tank can hold the pressure of 2.5 kg/cm^2)
5) Tank size is 250 mm*l50 mm*300 mm, volume is it is 11250 cc, then pesticide volume can be 6 to 8000cc and the remaining is being filled by the air. That is 3100 cc which requires 30 strokes for filling the air into the tank to effect the spraying at 1 kg/cm^2.

G. Helical torsion spring

A torsion spring is a spring that works by torsion; that is, a flexible elastic object that stores mechanical energy when it is twisted. The amount of force (actually torque) it exerts is proportional to the twisting force. A torsion bar is a straight bar of metal or rubber that is subjected to twisting (shear stress) about its axis by torque applied at its ends. Torsion fiber which is used in sensitive instruments consists of a fiber of silk, glass, or guAIZ under tension. One more type, a helical type if torsion spring, that is subjected to twisting about the axis of the coil): by sideways forces (bending moment) applied to its ends, twisting the coil by applying the more force to its ends, The terminology can be confusing because in a helical torsion spring the forces acting on the wire are actually bending stresses, not tensional (shear) stresses.

H. Torsion coefficient

According to Hook's law twisting is within the elastic limit

$$T = -k * \Theta \qquad (1)$$

Where the torque is exerted by the spring in Newton-meters, and theta is the angle of twist from its equilibrium position in radians. The spring constant 'k' is expressed in N-m/rad, it is also called as spring torsion coefficient, or just spring constant, which is equal to the torque required to twist the spring through an angle of 1 radian. It is analogous the spring constant of a linear spring. The energy (U) stored in a torsion spring is:

$$U = 0.5*k*\Theta^2 \qquad (2)$$

P = force exerted on spring.
M = Moment arm.
Θ = Deflection in degrees.
k = Spring constant.
Equation k = P * M/deg

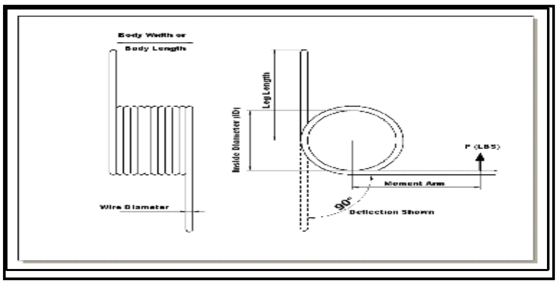


Fig -1: Torsion spring

When designing the torsion spring the load is taken into consideration**,** the spring diameter will decrease when the load is applied, which reduce the outside and inside diameters. The spring also increases its length; in most cases it is wise to design for torsion spring to wind in direction of the coil winding. Torsion spring is designed about a shaft. The shaft will ensure spring stability and location. Allow 10% clearance between the torsion spring and the shaft with spring at maximum deflection.

IV. MANUFACTURING PROCESS OF PARTS INVOLVED

Foot rest- This is made out of mild steel plate cut for the size of 90mm*l70mm from 2.5mm thick plate. This is then ground and finished for the edges to make the rectangular size with corner radius at all the corners. Such two numbers of plates are made for this project

*Cylinder flange-*This is made out of cold rolled closed annealed cold steel plate being cut from the sheet metal of 1 mm thick cut for the round shape of blank size 60mm and the hole size of 4mm, and then forming is done in the press tool of punch size 35mm and the die opening of 37.4mm to make the cup shape of internal diameter of 35mm and deep drawn for the depth of 1 2mm. This is then loaded to flare the hole to make the flange formed as per the sketch for the hole of 6.35mm for the depth of 1mm outside the outer face. This is then marked for the side holes of 5mm diameter at the center distance of 25mm between centers divided equally from the center. Such two numbers are made for this project.

Cylinder- This is made out of cold rolled closed annealed steel sheet of 0.8mm thick being cut for the blank and then stage wise it is formed and deep formed to make the cylinder with internal diameter as 5 1 .9mm for the length of 90mm. A hole is made of 1 *3* .5mm diameter to insert the outlet port. Such two tubes are made for this project.

*Outlet port-*this is made out of CRCA steel tube cut of diameter 12.7mm for the length of 24mm and then collar flanging is done by the press tool to make the collar diameter as 6.5mm keeping the total length20mm. Internal threading is done for the length of 1 0mm at the opposite side of the flange. Such two outlet ports are made for two different cylinders.

*Piston plates***-**This is made out of mild steel round plate of thickness 1mm cut from the diameter 55mm and then turned on lathe machine to make the diameter as *51* mm. Such two piston plates are required for one cylinder. Such totally four numbers are made for this project.

*Piston rod***-**This is made out ofC30 round bar of diameter 8mm being cut for the length of 115mm and turned on lathe machine for the diameter of 6.35mm for the entire length of 110mm and then step turned on lathe machine. Make the threading of M5 at both the ends for the length of 15mm each to suit the threading.

*Intermediate link***-**This is made out of mild steel flat of size 15mm of thick 2.5mm, being cut for the length of 120mm and then marked and bent to the required shape as shown in the sketch. It is then marked for the holes of diameter 6.35mm at two places and drilled the holes as per the sketch. Such four numbers of intermediate links are made for this project

*Floor rest***-**This is made out of mild steel flat of size 15mm of thick 2.5mm, cut for the length of 220mm and then bent as per the sketch to make it clear from the ground from touching, to minimize the contact area. It is then marked for holes of 6.35mm diameter and drilled four holes on the flat as per the sketch. Such four number of floor rest are used in this project

*Tank, shoulder held***-**This is a standard tank available for the pesticide spraying right now which has a hand pump provision to fixing. That port for the pump holding is now closed and used for this project. It has been made of high density polyethylene plastic in injection moulding in plastic moulding industry.

*Poly urethane tubes-*These are the standard tubes of diameter 6mm being used for this project for joining the foot cylinder to the tank and then from the tank to the spray nozzle holder.

V. SPRAYER

A sprayer is a device used to a liquid. In agriculture, a sprayer is a piece of equipment that applies herbicides, pesticides and fertilizers to agricultural crops; Sprayers range in size from man-portable units (typically with pray guns) to self-propelled units similar to tractors, with boom mounts of 60—151feet in length.

A. Sprayer Types

1) Backpack 2) Foot 3) Stirrup 4) Garden 5) Power and 6) Hand compression

The speed traveled while applying granules should be slow enough to prevent bouncing of the equipment as this causes uneven application. The application rate can be adjusted by changing the discharge opening. The actual rate of output must be checked during calibration.

Three variables affect the amount pesticide mixture applied per acre.

1. Nozzle flow rate,
2. Ground speed of the sprayer, and
3. Effective sprayed width per nozzle.

To calibrate a sprayer accurately the effect of each of these variables on sprayer output must be understood.

B. Spray application

One of the more common forms of pesticide application, especially in conventional agriculture, is the use of mechanical sprayers. Hydraulic sprayer consists of a tank, a pump, a lance (for single nozzles) or boom, and a nozzle (or multiple nozzles). Sprayers convert a pesticide formulation, often 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 wind conditions are required.

C. Nozzle flow rate

The flow rate through the nozzle varies with orifice tip size and nozzle pressure [3]. Installing nozzles with a larger or smaller orifice size is the most effective way to change the sprayer's output. Changes in nozzle pressure can also be used to increase or decrease sprayer output, but not as significantly as changes in orifice size. Pressure must be increased four times to double nozzle flow rate. Fr example, in order to increase the flow rate of nozzle from 0.25GPM at 20 psi to 0.50GPM, pressure would have to be increased to 80psi (4x20). It should never be used to make major changes. Most nozzles work best at pressures between 15 to 30 psi. Pressure below 15psi may distort the spray pattern, while pressures above 40psi will increase spray drift.

D. Ground speed

The spray application rate varies inversely with the ground speed. Doubling the ground speed of the sprayer reduces the gallons of spray applied per acre (GPA) by one half. For example a sprayer applying 20GPA at 3MPH would apply only 10GPA at a speed of MPH. A sprayer calibrated at 4MPH will over spray by 33 percent, significantly increased chemical socks and the potential for crop damage

E. Sprayed width per nozzle

The effective width sprayed per nozzle also affects the spray application rate. Doubling the effective sprayed width per nozzle will decrease the gallons per acre (GPA) applied by one-half. For example, if the nozzle is applying 40GPA on 20 inch spacing, a change to 40-inch spacing will decrease the application rate to 20GPA.

F. Measuring Ground Speed

To apply pesticides accurately, a constant ground speed must be maintained. Field conditions such as surface roughness, softness, and slopes will all affect ground speed due to wheel slip and significantly change application rates.

Tractor speedometers and tachometers are generally not a good means of determining ground speed because wheel slippage can result in speedometer reading errors of25 percent or more. Changes in tire size can also affect speedometer readings. The most accurate way to maintain a constant ground speed is with a special sprayer speedometer that runs by a non-driven wheel. These speedometers are available from a number of spray-equipment manufacturers at reasonable prices and are a good investment if a considerable amount of spraying is done. Many of the sprayer monitor switch are currently on the market also having the ability to accurately measure ground speed.

Average the two speeds and use the following equation or chart in Table 1 to determine the ground speed.

$$\text{Speed (MPH)} = D\ 60T^{*}\ 88 \quad (3)$$

D= the distance between the two stakes.

T= average time in seconds it takes to drive between the stakes. The numbers 66 and 88 are used because 1 mph = 88feet in 60 seconds.

Travel distance Table			
Nozzle spacing row (inch)	*Distance (ft)*	*Nozzle spacing row (inch)*	*Distance (ft)*
6	10.5	28	7.6
8	10	30	7.5
10	9.4	32	7.3
12	9.2	34	7.1
14	9	36	6
16	8.9	38	5.5
18	8.6	40	5
20	8.5	42	4.6
22	8.3	44	4.2
24	8	46	3.5
26	7.8	48	3

Table-1: Travel distance table.

1.GPM=OPM*128 (4)
2. GPA=GPM* 940xMPHxW (5)
3.GPA=OPM*5940*128*MPH*W (6)

GPA is the sprayer's output in gallons per acre. GPM = the nozzle output determined in Step 2 in Gallons per Minute. 5940 = a constant used to convert inches, gallons per minute, and miles per hour to gallons per acre. Using 6,000 makes the computation easier and results in an error less than one percent, MPH = the ground speed selected in Step 3in miles per hour.

W = the sprayed width per nozzle which was determined in Step 4 in inches.128 = the number of fluid ounces per gallon. For example, a pull-type field sprayer is set up to broadcast spray an herbicide with regular flat fan nozzles spaced 20inches on center. A ground speed of 5 mph has been selected. The average collected nozzle output is 54 OPM. What is the application rate in gallons per acre?

GPA=54*5940=25.06

A small nozzle volume change can generally be accomplished by either raising or lowering the pressure within the pressure limitations of the nozzle. A larger volume change can be accomplished by either changing the ground speed or by switching to larger or smaller nozzle tips. If 20 GPA was the desired application rate, a change in ground speed of 25/20*5.0=6.25 MPH would provide the desired 20 GPA without nozzle or pressure changes. From Table 1 this would require that a ground distance of 204 feet be covered in 20 seconds

VI. NOZZLE SPRAY PATTERNS

A.Hollow cone and solid cone-nozzles produce a circular pattern. Hollow cone nozzles generally make finer, smaller particles than the solid cone. These nozzles are used on handgun sprayers and row crop sprayers. They generally penetrate foliage well and are used to apply fungicides, insecticides and sometimes herbicides.

B. Nozzles are used to broadcast most types of pesticides. The pattern is fan shaped with gradually tapered edges. Uniform coverage across the sprayer width is achieved by overlapping the tapered portion of the pattern. This is also a common spray pattern used for applying structural pesticides to floor or wall surfaces.

C. Nozzle tip resistance to wear

Nozzle tips are made from a variety of material. The most commonly used material are stainless-steel, nylon, and brass, Tips made of hardened stainless steel, ceramic, Alumax, kemetal are where extra-long wear is desired.

In tests of nozzles using an abrasive chemical, the wear after 25 hrs was rated on scale of 0 to 24 as follows,

Tip material rating scale amount of wear.

Material	Rating Scale of wear (%)	Severity
Alumax	0	No
Ceramic	1	Little
Nylon	2	Little
Stainless Steel	4	Little
Brass	24	Rapid

Table -2: Nozzle tip wear rate

VII. FOOT WALKING PETICIDE SPRAYING PUMP

1. A small portable sprayer with ease of use. Fine droplet size (mist spray) due to nozzle improvisation.

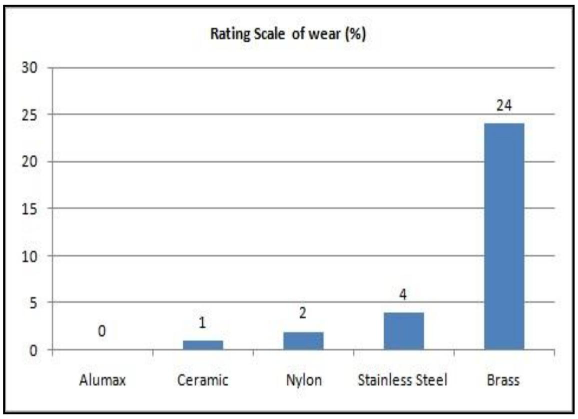
2. Light weight makes it maneuverable for aged people and also for women.

3. Maintenance free.

4. Energy derived from environment of feet hue walking is converted into pressure. Thus in turn enables the spraying of the liquid.

5. No additional energy is required to operate the sprayer. Operator can cover two parallel rows simultaneously and thereby cut down the operation cost and time by half.

This mechanism which is fitted on our foot will be activated when our kinetic force being applied on it. That is when we stamp our foot on the ground. This will be activated to push up assembly to pump in air to the tank. This power is very less but sufficient enough to use the pressure for spraying the pesticide. The pumping of air is done every time we walk. The mechanism is on both the foot will work simultaneously one after the other. The human foot is unique in the animal kingdom. It possesses inherent qualities and abilities far beyond other animals. We can move bi-pedially across the roughest terrain. We can balance on one foot we can sense the smallest small grain of sand in shoes. In fact, we have more nerve endings in our feet than our hands. We literally roll forward, rearward, laterally and medially across the bony structures of the foot. The key word is roll. “The muscles of the foot and ankle system provide a controlled acceleration of forces laterally to medially and vice-versa across the bony structure of the foot. In bio-mechanical terms these motions are referred to as pronation and suspiration. The foot is almost never applied flat, in relative position to the ground. Yet shoe designers continue to anticipate this event. This sole is operative to store and release energy resulting from compressive forces generated by the person’s weight on the support surface. Power Output for human walking and running.



Graph-1: Rating of wear

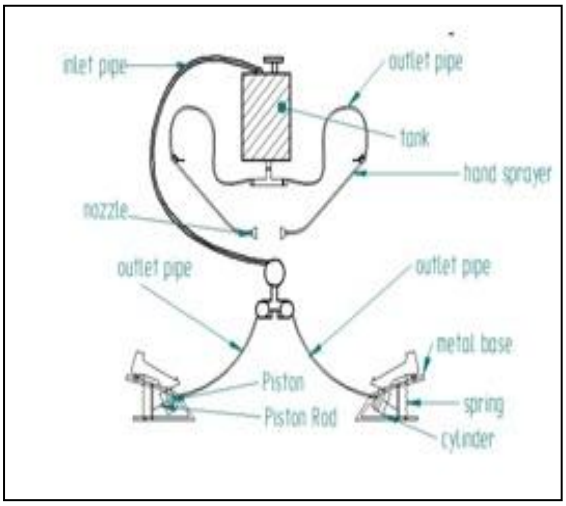


Fig -2: Model of Foot Operated pesticide Spraying Pump

A. MANUFACTURE PROCESS OF PARTS INVOLVED

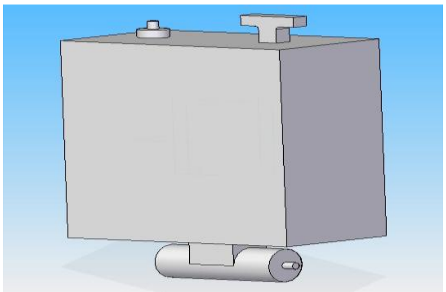


Fig -3: Tank

Fig -4: Foot Step

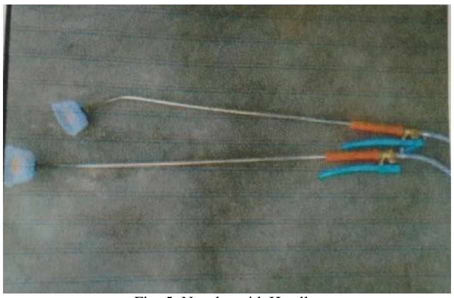
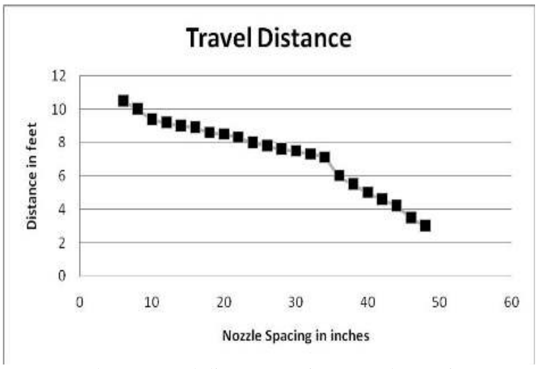


Fig -5: Nozzles with Handle

B. CALCULATION

To calculate total GPM per side
GPM= [(Speed mph)*(Row spacing ft/2) *GPA]/495
Example: Suppose to apply 100GPA while travelling at 2.5mph and rows are spaced 40ft apart what are required GPM per side?
GPM= [(2.5MPH)*(40ft/2)*(100GPA)]/495
GPM (per side) =10.1
Determining nozzle size &Flow rate:
NFR= Flow Required / Number of Nozzle
Example: If Flow Rate is 6.77 GPM & 2 Nozzle used.
NFR=6.77/2=3.385 GPM per Nozzle
Number of nozzle= Flow required / Flow per nozzle
Example: Flow required is 6.77 GPM & flow per nozzle is 3.385 GPM.
No. of Nozzle= 6.77/ (3.85) =2.0

VIII. RESULTS AND DISCUSSION



Graph-2**:** Travel distance against Nozzle spacing.

The above graph shows the travel distance. As nozzle distance increases the distance travelled by the droplet reduces. In order to reach at the more distance the pressure applied on the foot rest must be more. At the same time the nozzle with suitable design is to be selected. It finds more usefulness for an adult person with weight more than 50Kg.

IX. APPLICATIONS

1. Used for spraying pesticides in gardens
2. Can be used for painting automobile bodies
3. Can also be used for painting walls
4. Used for cleaning building and glass
5. Used to control the insects for money plants which are planted in gardens, houses and parks etc.

X. CONCLUSIONS

The foot walking pesticide spraying machine is fitted on the foot activated by kinetic force being applied on it, when we stamp our foot on the ground, pushing the assembly to pump air into the tank, the power is very less but sufficient enough to use the pressure for pesticide spraying. Since we are using two numbers of pumps which pumps the air into the tank and has two number of jet sprayers, we can cover two parallel rows simultaneously and thereby cut down the operation cost and time by half. This machine helps the farmers to speed the pesticide spraying. 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 nozzles should be used in the field for better performance. Muscular problems are removed as there is no need to operate the lever. This alone pump can used for multiple crops.

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