



e-ISSN: 2319-8753 | p-ISSN: 2347-6710

IJRSET

International Journal of Innovative Research in
SCIENCE | ENGINEERING | TECHNOLOGY

INTERNATIONAL JOURNAL OF INNOVATIVE RESEARCH

IN SCIENCE | ENGINEERING | TECHNOLOGY

Volume 10, Issue 12, December 2021

ISSN INTERNATIONAL
STANDARD
SERIAL
NUMBER
INDIA

Impact Factor: 7.569

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Design and Simulation of Mechanically Operated Fluid Sprayer

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ABSTRACT: In order to meet the food requirements of the growing population and rapid industrialization, modernization of agriculture is inescapable. Mechanization enables the conservation of inputs through precision in metering ensuring better distribution, reducing quantity needed for better response and prevention of losses or wastage of inputs applied. Mechanization reduces unit cost of production through higher productivity and input conservation. Our project does not need any secondary source of energy to operate, all it needs is a little push. Since it is not using any sources to operate it does not leave any residual substances which may be harmful for the environment. Since it uses a mechanism which converts rotary motion from the wheel to reciprocating pump action it does not need any skilled labour for operation making it easy to handle and economical to use. Though being a hand pushed cart it gives you an even spray over the area it needs to be used

KEYWORDS: Fluid Sprayer, agricultural sprayer, mechanical sprayer.

I. INTRODUCTION

A sprayer is a device used to spray a liquid, where sprayers are commonly used for projection of water, weed killers, crop performance materials, pest maintenance chemicals, as well as manufacturing and production line ingredients. In agriculture, a sprayer is a piece of equipment that is used to apply herbicides, pesticides, and fertilizers on agricultural crops. Sprayers range in size from man-portable units to trailed sprayers that are connected to a tractor, to self-propelled units similar to tractors, with boom mounts of 4–30 feet up to 60–151 feet in length depending on engineering design for tractor and land size.

Sprayers are fully integrated, mechanical systems, meaning they are composed of various parts and components that work together to achieve the desired effect, in this case: the projection of the spray fluid. This can be as simple as a hand sprayer attached to a bottle that is pumped and primed by a spring-lever, tube, and vacuum-pressure.

For more complex sprayers, such as agricultural sprayers, common system components include: the spray nozzle, sometimes with a spray gun, fluid tank, sprayer pump, pressure regulators, valves and gaskets, and fluid plumbing. The sprayer pump can be just as important as the sprayer type itself as there are many sprayer pump design types with various construction materials, inlet/outlet sizes, and performance specifications. Common sprayer pump types include diaphragm, centrifugal, and roller pumps.

Agriculture sprayers come in various design types, sizes, equipment and performance specifications. They range from small spot-spraying machines to very large sprayers with extensive land and plant coverage. Agricultural sprayers have been engineered to optimize their applicability and performance for the many purposes that the machines are put to, whether being used on crops, vegetation, or soil. Agriculture sprayers are often used for applying water and water/chemical solutions containing acids or caustic materials for crop-performance or pest-control; i.e., fertilizers and pesticides.

Day by day the population of is increasing and to fulfil the need of food modernization of agricultural sectors is important. Due to chemical fertilizers the fertility of soil is decreasing. Hence farmers are attracted towards organic farming. By mechanization in spraying devices fertilizers and pesticides are distributed equally on the farm and reduce the quantity of waste, which results in prevention of losses and wastage of input applied to farm. It will reduce the cost of production. Mechanization gives higher productivity in minimum input. Farmers are using same traditional methods for spraying fertilizers and pesticides.

In India there is a large development in industrial sectors compared to agricultural sectors. Conventionally the spraying is done by labors carrying backpack sprayer and fertilizers are sprayed manually. The efforts are more and beneficial by farmers having small farming land. Mechanization gives higher productivity with minimum input. Farmers are using same traditional methods for spraying fertilizers and pesticides. Equipment is also the same for ages.

Generally, a mechanization of small forms is very difficult and non-affordable. Demand for agriculture is rising rapidly with increase in population and per capital income and growing demand from industry sector. There is, thus, an urgent need to identify severity of problem confronting agriculture sector to restore its vitality.

In this agriculture sector there is a lot of field work, such as weeding, reaping, sowing etc. Apart from these operations, spraying is also an important operation to be performed by the farmer to protect the cultivated crops from insects, pests, funguses and diseases for which various insecticides, pesticides, fungicides and nutrients are sprayed on crops for protection. Farming has undergone a great evolution in last 50 years. Out of the various reasons involved for this evolution is control of various diseases on crops. In the modern agriculture, the usage of pesticides is still increasing moreover the 90% of these pesticides are being applied in the form of spraying which will maintain environment friendly approach. The argument for using existing conventional equipment is that farmers will face economic difficulties in case of chemical and electrically powered pumps as well as they will face health issues in case of hand operated pumps. One way to overcome this problem is to use the equipment developed for application of the pesticides through the use of mechanical power. In selecting a pump for furnishing a supply of pesticides for farm use, or for spraying insecticides, have sufficient capacity to supply the needed amount of water and spray material in the allowable time.



Fig (a): Common spraying methods

II. RELATED WORK

The Food and Agriculture Organization (FAO) has defined pesticide as: Any substance or mixture of substances intended for preventing, destroying, or controlling any pest, including vectors of human or animal disease, unwanted species of plants or animals, causing harm during or otherwise interfering with the production, processing, storage, transport, or marketing of food, agricultural commodities, wood and wood products or animal feedstuffs, or substances that may be administered to animals for the control of insects, arachnids, or other pests in or on their bodies. The term includes substances intended for use as a plant growth regulator, defoliant, desiccant, or agent for thinning fruit or preventing the premature fall of fruit. Also used as substances applied to crops either before or after harvest to protect the commodity from deterioration during storage and transport.

S.R. Kulkarni et.al [1] did a research on “Fabrication of Portable foot operated agricultural fertilizer and pesticide spraying pump”. 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.

T. Subbarayudu and Dr. N Venkatachalapathi [2] did a research on “Modelling and development of pedal operated agricultural sprayer”. The main aim of this project is to minimize the human effort and to increase the speed ratio between pedal operation and reciprocation of the pump and discharge rate in the sector of manual sprayers. In this project the foot sprayer can be modelled, developed and fabricated. This sprayer is also invented to easy operation and transport from the one field to another field. It can be operated by both the legs at a time so that the applying load will be distributed equally to both the legs of the operator. This pedal operated sprayer is implemented by introducing the crank mechanism which converts rotary motion into linear motion. Then the frame and reciprocating pump will be designed by using design software CATIA (Computer Aided Three-Dimensional Interactive Application). The different parts are piston, pushrod, plunger, crank mechanism, pedal mechanism, suction pipe with strainer and delivery pipe with gun or lance. This project will help farmers in the agriculture for the purpose of pesticides and insecticides spray to control field crops and orchards.

Harold R. Summer and Gary A. Herzog [3] did a research on “Assessing the Effectiveness of Air-assisted and Hydraulic Sprayers” Compared with conventional over-the-top sprayers, air-assisted and drop-nozzle sprayers should provide improved pesticide penetration and coverage within the plant canopy where the insects feed. This study compared the effectiveness of the insecticide Tracer, a natural insecticide produced by the actinomycete *Saccharopolyspora spinosa*, (Dow Agro sciences, Indianapolis, IN) applied by these three sprayers within the canopy of cotton (*Gossypium hirsutum* L.). Leaves from the top, middle, and bottom of cotton plants were used in a bioassay as an indicator of insecticide deposition within the canopy. The test measured the mortality of beetle armyworm (*Spodoptera exigua*, Hübner) larvae feeding on the sampled leaves. All three sprayers provided adequate coverage for good insect control in the top of the cotton canopy. The air-assisted sprayer provided the best insect mortality throughout the canopy, while the over-the-top sprayer had the poorest insect mortality in the bottom. Air-assisted and drop-nozzle sprayers provided good insect mortality in the middle of plants.

Manoj Kumar Patel [4] did a research on “Technological improvements in electrostatic spraying and its impact to agriculture” An important aspect of research in electrostatic force field applications to liquid sprays involves pesticide spraying, painting, printing, thin film coating, medical, Nano biotechnology, transportation etc. The desired attributes of such spraying are uniform deposition onto both directly exposed (adaxial) and obscured (abaxial) crop surfaces which minimizes the off-target losses of active ingredients to soil, water, atmosphere and provides economic pest control. This paper presents an overview of electrostatic spraying technologies in the field of agriculture and perishable fruits/food products emphasizing the key role of advanced electrostatic spraying instrumentation and chronicles the scientific innovations in the parlance of providing cost effective and reliable commercial systems along with an insight on the needs of future research perspectives and directives.

J.O Awulu and P.Y Sohoshan [5] did a research on “Evaluation and Development of Electrically Operated Knapsack sprayer” An electrically operated knapsack sprayer of ten (10) litres capacity was developed using locally available materials and its performance evaluated. This device is developed to reduce the constant application of energy to throttle to regulate air pressure a problem in conventional knapsack sprayers. The major components include; tank, 12 volts electric water pump, 12 volts accumulator battery, strap (belt), delivery pipe and a sprayer handle together with lance and nozzle. Electric water pump that bended with the designed parameter was Mercedes Benz windscreen washer pump, powered by 12 volts, 2.5 amperes battery (motorcycle type). Laboratory and field tests were conducted to determine flow rate, application rate and distribution rate. Basic hydraulic principles were considered for determining flow rate, while application rate was determined by effective use of walking speed on field. The results showed that the sprayer has a flow rate of 531 ml, application rate of 250 l/ha and a spray distribution area of 0.000675 m². The result from the laboratory test indicated that decrease in liquid head leads to decrease in flow rate and vice versa. Efficiency of spray decreased with decrease in voltage of battery and application rate is influenced by walking speed. The sprayer is capable of spraying 250 l/ha in 4.17 hrs. at a walking speed of 0.7 m/s. This device cannot be operated continuously for more than 2 hrs. due to decrease in voltage. It is advisable for extra batteries to be carried along to the farm for large hectares spraying.



Menzies, D.R [6] has done the research on “Design of an experimental sprayer forpesticide application” studies in orchards. An experimental orchard sprayer wasfabricated for use in pesticide application studies. Its design features three independentlycontrolled vane-axial fans, vertically stacked and driven hydraulically, three pesticidenozzle manifolds, and provision for altering the air outlet geometry. Use in experimentalprograms has confirmed it usefulness.

A. S. Wankhede and et.al [7] have reviewed on “Development of multipurposesprayer” Automation for spraying in the field of agriculture has increased theproductive output of the farms. Owing to this, labour problem has been solved. But thescenario in the country like India is different. The agriculture field being small,automation is such places are a difficult task also the economic condition of majorityof Indian farmers is not well to do. Therefore, the manually operated sprayer finds wideapplication in such condition. In Indian farms two types of sprays are used: Handoperated and Fuel operated pump. The main drawn back of hand operated spray pumpis that the user cannot use it for more than 5-6 hours continuously as he gets tiredwhereas fuel operated spray pump requires fuel which is expensive and availability offuel is not easy at rural places. In such situation we should think to move towards nonconventionalenergy. This review paper tries to develop a new mechanical systemwhich will overcome all the above problems and will help farmers to.

III. DESIGN

The frame structure is made from square section MS pipe. Backpack sprayertank is mounted on the tank base plate of the main frame. Single front wheel of dia240mm is used as the connected to the handle for steering the sprayer machine in theforward direction. Two ear wheels of dia 740mm is used for generating the requiredpressure by the slider crank mechanism which has standard sprockets of diameter65 mm and 121mm and 14 mm thick with 16 teeth on the smaller sprocket and 30 teethon the larger sprocket and the chain length is approximately 1.02m. Eight nozzles withknobs are placed on the front supporting rod which are used for spraying the fluids.

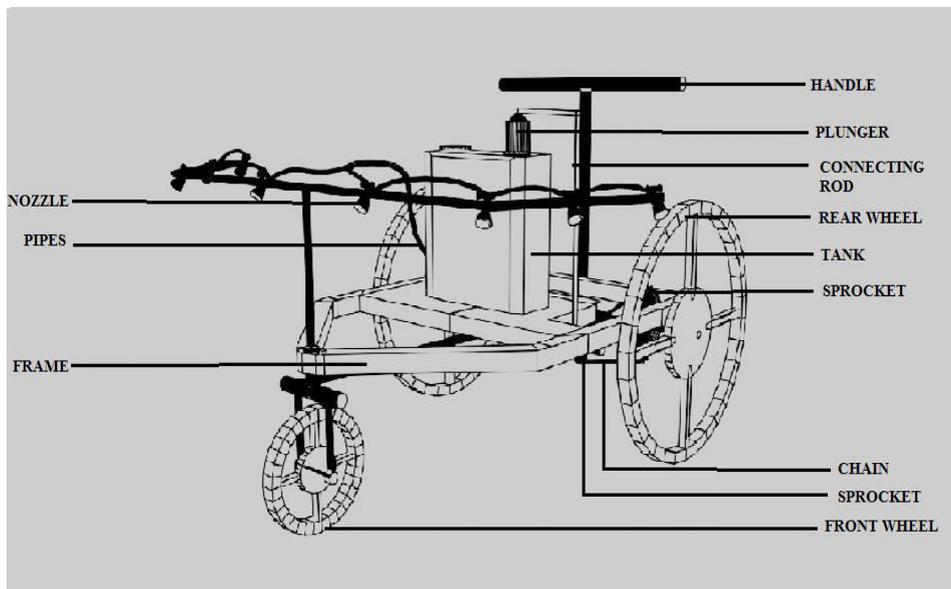
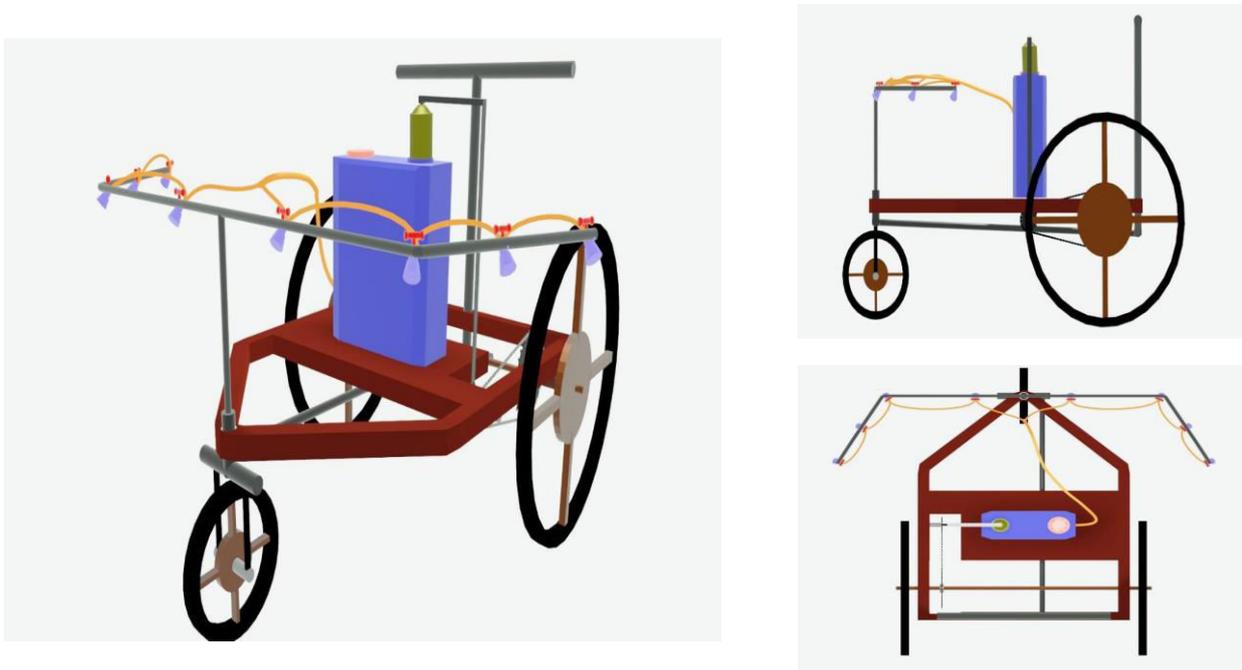


Fig (b): Parts View of the model



Figure(c): Views of the model

The frame is made from MS pipe of diameter 10 mm, cut to the different length as required, all are ground to remove the cutting burr and joined by arc welding to make the rectangular frame. This frame is then marked at the center of the length and drilled to the required measurement to have the hole which has to be insert to the wheel axle. Wheels are assembled in the holes with the axle at both the sides as required.

The wheels are standard bicycle tyres of diameter 740 mm with rim, spokes, spindle with hard tubeless rubber tyres. Such 2 numbers of wheels have been used. And another smaller wheel of diameter 240mm for the front wheel. The standard sprockets being used in bicycle with outer diameter of 65 mm, 14 mm thickness and with 16 number of teeth and another of the outer diameter 121mm and with 30 number of teeth and standard chain of 8 mm roller chain being used in bicycle are used for the power transmission. The length of the chain is 1016mm. The fluid tank is standard backpack sprayer pump with piston attached to it. It is kept over the frame and placed firmly. It is run through the slider-crank mechanism, which in turn is driven by the gears.

Table 1: List of Materials with dimensions

Parts	Material and Dimensions
Handle	Mild steel –dia 10 mm- Circular section
Frame	Mild steel - 15mm x 15mm – Squarecross section
Wheel -Front Wheel -Rear Wheel	Rubber wheel - dia 240 mm Rubber wheel - dia 740 mm
Power transmission-Chain drive -Pinion wheel -Gear wheel -Length of chain -Chine link pitch -Connecting rod	16 teeth - dia 65mm 30 teeth - dia 121mm 1016mm (using open belt method) 12.7mm 10mm x 10mm - Length 600mm - Square section



Sprayer tank - capacity	350mm x 120mm x 420mm (L x B x H) 17.6 Liter or 17600 cubic centimetre
Front 'T' rod	Mild steel - dia 10 mm - circular cross section
Pipe and splitters	According to requirement
Nozzles	8 numbers

IV. WORKING PRINCIPLE

This sprayer mechanism is designed to convert the forward motion into the required pressure for spraying the fluids in the tank. When the cart moves in the forward direction, the rear wheels, along with the rear wheel axle will rotate thereby rotating the chain sprocket assembly. The gear is meshed to the shaft which will also rotate. This rotational motion will generate the required torque on the driven sprocket which is connected to the connecting rod and the plunger assembly. The plunger compresses the fluid inside the tank to the required pressure and the fluid is sprayed through the nozzles. The nozzles are so placed such that they cover a larger spray surface and also knobs are provided so that when the nozzle is not required in a particular direction, it can be closed.

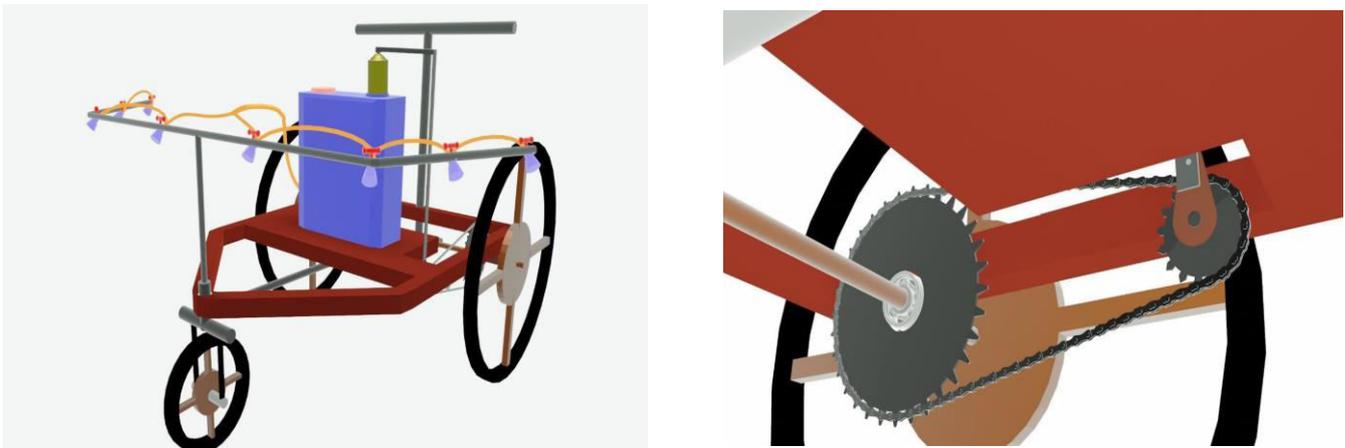


Figure (d): Assembled view of the Sprayer and power transmission

Advantages:

- No power or fuel consumption, so economically viable and also environmental friendly. Maintenance cost is also very less
- It can be used for spraying fluid fertilizers, pesticides.
- Ergonomic design reduces human effort
- Larger spray area can be covered as there are 8 number of nozzles.
- This can be used for multiple crops with height and row adjustment options.

V. CONCLUSION

This sprayer mechanism is ergonomically designed to reduce the human effort while spraying pesticides or fertilizers in agricultural fields. This mechanism is driven by the forward motion of the complete assembly thereby reducing the power or fuels used to run such sprayer machines. This design with 8 sprayers can cover a larger spray



area and reduce the time for spraying of the fluids and also the nozzles can be adjusted as per the requirement. This sprayer can also be used for application of sanitizers on walls, floors and closed spaces.

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