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Mechanically Operated Cart for Pesticide Sprayer for Agriculture

Faijubhai Malek [1], Dipam Patel [2], Yash Padia [3], Mit Kundariya [4], Varun Jarsania [5]

Asst. Professor, Department of Mechanical Engineering, GCET College, Vallabh Vidyanagar, Gujarat, India[1]

Student, Final Year, Department of Mechanical Engineering, GCET College, Vallabh Vidyanagar, Gujarat, India[2]

Student, Final Year, Department of Mechanical Engineering, GCET College, Vallabh Vidyanagar, Gujarat, India[3]

Student, Final Year, Department of Mechanical Engineering, GCET College, Vallabh Vidyanagar, Gujarat, India[4]

Student, Final Year, Department of Mechanical Engineering, GCET College, Vallabh Vidyanagar, Gujarat, India[5]

ABSTRACT: The project is intended to help the farmers as India being an Agriculture based country. It is a Pesticide Sprayer mounted on a Cart which is operated mechanically without any external source of energy. The aim of developing such a concept is primarily because of preventing the 3 major drawbacks of the pump being used currently- Firstly, the farmer has to carry the entire weight of the pesticide spraying (approx. 20+ kg) pump on his shoulder; secondly, he has to continuously use his one hand to pump using the handle; thirdly, the farmers don't take enough precaution which results in fatal diseases because of direct contact with the chemicals. All these factors have been taken care of in this project along with being cost effective, light in weight and good in strength. The pump already available with the farmer can be directly used in this mechanism. The handle of the sprayer will be mechanically operated through the rotating shaft of the wheels of the cart using an efficient mechanism. This will result into the reciprocating motion of the piston and hence pumping will be done. The user will now just have to pull the cart and the whole mechanism will be operated with ease. This will be a case of Pure Mechanical Automation.

KEYWORDS: Pesticide Sprayer, Trolley, Slider-Crank Mechanism, Mechanical Automation.

I. INTRODUCTION

India is a land of agriculture which comprises of small, marginal and rich farmers. Small scale farmers are interested in manually lever operated knapsack sprayer because of its versatility, cost and design[5]. As the pests and insects nowadays have been growing up in abundance throughout the vegetation and also having developed their immunity towards the surrounding environment, it becomes compulsory for the farmers across the globe to spray pesticides and insecticides frequently in order to protect their crops from getting rotten and consumed by insects.

Protection from parasites is an important factor in all the agricultural operations, and calls for continual monitoring and prompt action when needed. In many cases, different equipments, pesticides and manpower are required for this purpose which accounts for the majority of production expenses. This would ultimately affect the economy of the farmer, hence it needs serious consideration.

II. RELATED WORK

There has been a deep research in this field since a longtime to improvise the efficiency of the pesticide sprayers and provide comfort to the operators. There are mainly 3 different kinds of pumps available in the market[3]

a. Manually Operated Spray Pumps
b. Fuel Operated Spray Pumps
c. Electrical Operated Spray Pumps (using renewable/non-renewable sources)

Other available designs are-

- Robot Operated
- Aerial Operated

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- Solar Operated

Despite the availability of these designs, there are drawbacks for each mechanism-

- In conventional sprayer, constant pumping is required to operate this sprayer [5].
- The solar sprayer is extremely heavy to carry and has high initial cost [2].
- Autonomous sprayer can only be used where a specified path is available like in a greenhouse because it needs guide ways [1] [8].
- The wheel and pedal operated sprayer requires specially designed tank and also the weight of the operator is included in the mechanism [4].
- The multi-nozzle sprayer is difficult to manufacture and high initial cost [5].
- The multiple powered fertilizer sprayers cannot function efficiently in monsoon and also faces battery discharging problems [6].
- Automated aerial sprayer needs skilled person for operation and cannot function during windy and rainy atmosphere [9].
- The fuel operated sprayer requires fuel continuously which at a long run pollutes the environment and also incurs running cost.

III. AIM AND OBJECTIVES OF THE PROJECT

The ultimate aim of this project is that the farmer need not carry the entire pesticide sprayer pump on his shoulders but just pull the mechanism mounted on the trolley to operate the pump and spray the pests. This makes the farmer feel comfortable, relaxed and less tiresome. The second aim is to reduce human efforts due to the constant pumping action for creating pressure inside the pesticide sprayer and thereby provide a suitable environment for the user reducing the fatigue load acting on the body.

As discussed previously, the farmer has to continuously keep on pumping using one of his hands and spray the pests on the crops using the other hand. This at a long run is a tiresome and cumbersome job and the farmer slowly looses interest from it. The final objective of this project focuses on the problem of health related issues of the farmer (operator). Majority of them don't use any precautions like face-masks and hand-gloves against the hazardous chemicals and work in direct contact with it. Consequently, this harms the farmer as the spray in the conventional method directly hits the face.

IV. PROBLEM SPECIFICATIONS

The major problems being faced currently are:

- Heavy Load to be carried on Shoulders
- Continuous Pumping using one Hand
- Direct Contact with the Hazardous Chemicals
- Random Spraying of Pesticides on Crops

IV.1 Proposed Design

The mechanism selected for the operation of the pump and less input efforts by the farmer is the 'Slider-Crank Mechanism'. Different components to be used for constructing the mechanism (prepared in the creo parametric 2.0 software) are shown in figure-1.

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(Figure-1. 3D Views of Different Components used in the Mechanism)

The mechanism will be mounted on the trolley having two large wheels. The conventional sprayer will also be mounted on the trolley base with its pumping handle removed. The slider in this case will be the piston pump of the sprayer. The connecting rod, which will pump the sprayer because of its reciprocating motion and which will be directly connected with the piston pump using a pin joint (in place of the handle removed). The shaft of the trolley will become the crank which will rotate when the trolley will be pulled by the user.

The shaft used here will be different than the other ordinary shafts available, as here it has to function as a crank for the mechanism. Hence, it will be a shaft with a U-Bend in its centre. Thus the connecting rod will be mounted on to the central part of the U-Bend, getting the advantage of eccentricity and producing output of a crank and imparting motion to the linkages.

The trolley when pulled will rotate the shaft; hence the U-bend component because of its eccentricity will transmit motion to the piston pump via the connecting rod. The pump will then start to build up pressure as the piston would be operated. The pressurized pesticide fluid will come out from the piston hole and supplied to the two outlet pipes mounted on top of the frame to throw out the spray to 2 rows of crops simultaneously.

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V. DESIGN OF PROTOTYPE

V.1 Design Specifications

❖ **Total Weight:**

Maximum stroke of pump = 8.5 cm => Required crank radius = $\frac{8.5}{2}$ = **4.25 cm**

Weight of Pump = **21.385 kg**

Approximate weight of empty pump = 4 kg

∴ Total Weight = 21.385 + 4
= **25.385 kg**

Note: For safety & design point of view, we will consider the total weight as **30 kg**.

Total Weight of trolley (trolley + pump) = 15 + 30
= **45 kg**

❖ **For Bending:**

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

∴ d = 3.67 ≈ **4 mm**

❖ **For Shear:**

$T_{all} = \frac{F}{A}$

$133.4 = \frac{225X4}{\Pi d^2}$

∴ d = 1.46 mm ≈ **2 mm**

❖ **Design of Shaft for Dynamic Loading:**

M = 1125 N
W = 450 N
R = 53.1 cm = 20.90 inch
F_r = Rolling Co-efficient

$F_{roll} = f_r \times \frac{W}{R}$

$= 0.004 \times \frac{450}{20.90}$ = **0.9 N**

$F_{friction} = \mu \times R_N$

= 0.75×450 = **337.5 N**

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T_{max} = **129.6 MPa**

$$T_{all} = \frac{16}{\Pi d^3} \times \sqrt{(K_t \times T)^2 + (K_b \times M)^2}$$

where,

K_b = Combined shock and fatigue factor applied to bending moment = 1

K_t = Combined shock and fatigue factor applied to torsional moment = 1

∴ d = 19.16 ≈ **20 mm**

V.2 Materials Required

The different materials to be used will be as follows-

1) For U-Bend Shaft- Mild Steel (55C8)
2) For Trolley Frame- Mild Steel
3) Roller Bearings

V.3 Cost Approximation

Based on the above calculations and market survey, the cost is approximated for the defined materials for the manufacturing of a prototype of the previously discussed design as shown in table-1.

Table-1. Cost Approximation

Components	Quantity	Cost (in Rs.)
Bicycle Wheels	2 pieces	450
Ball Bearings	2 pieces	120
Trolley Frame	7 m*	550
Shaft (EN 8 instead of 55 C8)	85 cm	160
Connecting Rod/ Nut-Bolt	125 cm	100
Nozzle Extension	900 cm	60
	Total Cost	**1440****

(*Approximately 15 kg of Metal will be required for the trolley design)
(**Excluding Manufacturing/Labour Cost)

Based on the customer requirements, the materials mentioned here are subjected to change depending upon the availability and cost involved.

VI. DESIGN IN ACTION

VI.1 Assembly of Prototype

The assembly of the prototype as shown in figure-3 is created keeping reference of figure-2. The assembly shown in figure-2 is created in the Creo Parametric 2.0 software. There are some major changes included in the real prototype as compared to the design created previously. These changes have been made keeping in mind the easy availability of the material, affordable prices, light in weight and manufacturing ease.

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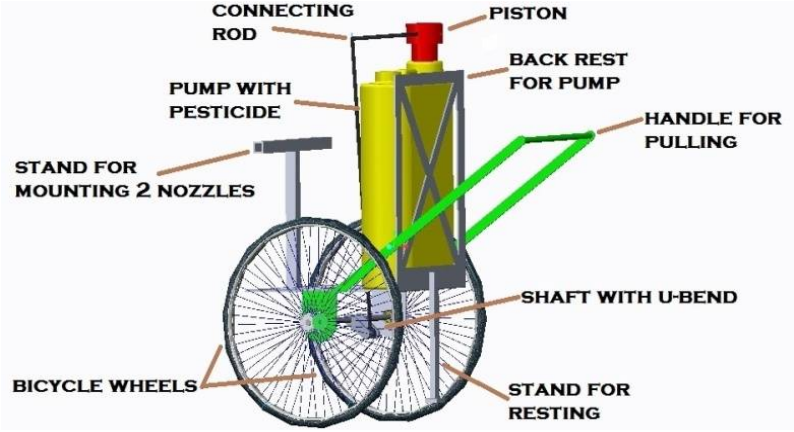

(Figure-2. Assembly Design of the Prototype created in Creo Parametric 2.0 Software)

VI.2 Simulation & Results

As depicted in figure-3, the mechanism will be kept at rest on the stand when not in use. The stand is available at the front end of the trolley. Whenever it is desired to move the trolley, the stand will be lifted up and the mechanism will pulled to operate. The weight of the trolley, pump and mechanism is entirely taken up by the bearings mounted on shaft of the wheels.

(Figure-3. Actual Assembly of Prototype with changes in Design)

The stand at the top of the frame in the front end is provided for hanging the 2 nozzle outlets in opposite direction such that it sprays in 2 rows simultaneously, thereby reducing the efforts of the farmer by half. The bicycle wheels are specifically preferred for the easy movement in the fields and portability because of it being light in weight. Hence, the efforts with pulling the trolley will be reduced significantly. The handle for pulling can be operated directly using one hand of the operator.

VI.3 Operational Parameters

The mechanism is operated only using human power. The worker just has to pull the mechanism similar to the travelling bag with minimal possible efforts.

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When 1 revolution of the U-bend shaft occurs, 1 stroke is operated in the pump. The operation of 1 stroke takes about 4 seconds. As soon as the piston reciprocates, the outlet of the pesticide starts. After the 1st stroke is completed, the output of the pests continues for 6 more seconds.
Similarly, for 5 strokes, it takes about 18 seconds for their complete operation. After the 5 strokes are completed, the output of the pests continues for 15 more seconds.

VI.4 Advantages of Proposed Design over Other Designs

- ✓ Less Initial and Maintenance cost
- ✓ Does not require any External Source of Energy
- ✓ Safe for Operation
- ✓ No Fatigue to Operator
- ✓ Does not require to buy any Specially Designed Pump (conventional backpack pump can be directly used here)
- ✓ Can work Efficiently during all Seasons
- ✓ Uniform Spraying
- ✓ Portable & Ergonomic
- ✓ No Running cost

VI.5 Drawbacks of Proposed Design

- It is difficult to balance the ratio between Cost, Weight and Strength of the mechanism to be created.
- Difficult to convince the farmers for using a new design.
- Problem in using Tyre-Tubes
- Corrosion at a longer run

VII. SUMMARY

The Mechanically Operated Pesticide Sprayer is a perfect substitute for the conventional sprayer used everywhere. The crank-slider mechanism connected directly on the U-bend shaft uses the shaft power. Because of eccentricity of shaft it would reciprocate the piston and hence pressure would build up inside the pump.
The pressurized liquid is directly allowed to release through the 2 output nozzles and lands on to the adjacent parallel rows of crops. The trolley and shaft material would be made up of Mild Steel and the Wheels used will be that of Bicycle. The farmer will just have to apply efforts for pulling the trolley which is far less than lifting the entire weight of pump and walking. It would turn out to be an efficient design for the farmers reducing their efforts drastically.

VIII. CONCLUSION

Thus it is concluded that the 'Mechanically Operated Pesticide Sprayer' using the 'Crank-Slider Mechanism' is much better as compared to the other different type of options available. It is a case of complete 'Mechanical Automation' as no external power sources will be employed in its operation. Moreover, various materials selected for the entire mechanism will be easily available at a considerably affordable price.
The main problem being faced by the farmer was to carry the entire load of the pests on his shoulder and this problem can be very efficiently solved by the adoption of this method. Also, very fewer efforts are needed to be applied for its working on the real-situation fields. In addition to that, no special skills or training is required for the farmer (operator) to operate it.

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