Journal Homepage: - www.journalijar.com
INTERNATIONAL JOURNAL OF ADVANCED RESEARCH (IJAR)
Article DOI: 10.21474/IJAR01/3884
DOI URL: http://dx.doi.org/10.21474/IJAR01/3884
ISSN NO. 2320-5407

RESEARCH ARTICLE

DESIGN AND FABRICATION OF WHEEL DRIVEN SPRAYER.

V. Pranavamoorthi[1], R. Pravinyadav[1], D. Sivaramakrishnan[1], V. Tamilarasan[1], Mr. A. Mahabubadsha[2] and Dr. K. Anandavelu[3].

1. Final Year Mechanical Engineering, M.R.K Institute of Technology, Kattumannarkoil, Tamilnadu, India
2. Assistant Professor, Mechanical Engineering, M.R.K Institute of Technology, Kattumannarkoil, Tamilnadu, India.
3. Professor, Mechanical Engineering, M.R.K Institute of Technology, Kattumannarkoil, Tamilnadu, India

Manuscript Info

Manuscript History

Received: 07 February 2017
Final Accepted: 05 March 2017
Published: April 2017

Key words:-
Usability, Functionality, Ergonomics, Wheel Driven, Multi Nozzle

Abstract

India is said to be an agricultural base country directly or indirectly 75% of the peoples are dependent on farming, 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, fungi and diseases for which various insecticides, pesticides, fungicides and nutrients are sprayed on crops for protection.

In today's world, one use many different spraying technologies using energies like electrical energy, solar energy, and chemical energy of fuels. This fact makes one know that how large amount of energy is getting used at such place where mechanical energy can be used instead of direct energy sources. Farmers are facing enormous problem while spraying the pesticide like tank capacity is very small, high cost and spaying time taken more. In order to reduce problems different type of sprayers has been introduced in the market, but these devices do not meet the specified problems or demands of the farmers. To solve these difficulties a new equipment that is mechanically operated wheel driven sprayer, it is a portable device and does not need any fuel to operate, which is easy to move and spray the pesticide by moving the wheel is to be developed. This wheel operated pesticide spray equipment consumes less time and achieves uniform nozzle pressure; crank mechanism with piston pump which is driven by the wheel is also used. The main aim of the paper is to be develop a low cost mechanically operated sprayer pump for Indian middle scale farmers. The device has been validated with the user group and got good feedback from the user.

Introduction:-

Farming is the backbone of Indian economy. Agriculture sector includes is a lot of field work, such as weeding, reaping, sowing etc. Apart from these operations, spraying is also an another important operation to be performed by the farmer to protect the cultivated crops from insects, pests, funguses and diseases for which various insecticides,

Corresponding Author:- V. Pranavamoorthi.
Address:- Final Year Mechanical Engineering, M.R.K Institute of Technology, Kattumannarkoil, Tamilnadu, India.

pesticides, fungicides and nutrients are sprayed on crops for protection. Farming has undergone a great evolution in last 50 years. Control of various diseases on crops is an important reason for this evolution.

In the modern agriculture, the usage of pesticides is still increasing.Moreover 90% of these pesticides are being applied in the form of spraying which maintains a environment friendly approach. The argument for using existing conventional equipment is that farmers will face economic difficulties in case of chemical and electrical powered pumps and will also face health issues in case of hand operated pumps. One way to overcome this problem is the use of 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, herbicides or fungicides, one may be sure that it was designed for the job to be done. The unit should have sufficient capacity to supply the needed amount of water and spray material in the allowable time.

Methods and Methodology:-

- Data collection would be done by literature survey, user study and market study through questionnaires, videos and observation etc.
- QFD generation based on the user requirements and corresponding technical requirements, and PDS would be generated by prioritizing the features in the QFD
- Concepts would be generated by sketching and digital Modeling
- Generate the doodle sketches and come out with five concepts and the digital model will be created with the detailed features using CATIA software.
- Concept evaluated and final concept selected using weighted ranking method
- Working model would be made with detailed features and feedback would be collected.

Literature Survey:-

Sudduth K.A., Borgelt S.C., Hou J., (1995) Performance of a chemical injection sprayer system, Abstract - Performance of a chemical injection sprayer system, found the time delay of concentrated pesticides through injection sprayers to be significant, and proposed injection at the individual nozzles as a possible solution to shorten delays. Development of a direct nozzle injection system that overcame the concentration variation problems reported by previous researchers. Simulation are used to compare chemical application accuracies for various designs of injection sprayers. They found that reducing the diameter of the fluid lines near the end of the spray booms improved overall application accuracy.

Way T.R., Von Bargen K., Grisso R.D., Bashford L.L., (1992) Simulation of chemical application accuracy for injection sprayers. Abstract - An autonomous mobile robot for use in pest control and disease prevention applications in commercial greenhouses. They develop the robot platforms ability to successfully navigate itself down rows of a greenhouse, while the pesticide spraying system efficiently covers the plants evenly with spray in the set dosages. The main application of robots in the commercial sector has been concerned with the substitution of manual human labour by robots or mechanized systems to make the work more time efficient, accurate, uniform and less costly.

Philip J. Sammons, Tomonari Furukawa, Andrew Bulgin, (2005) Autonomous Pesticide Spraying Robot for use in a Greenhouse, Abstract - The University of Nairobi develop the system like centrifugal pump is the most common non-positive displacement pump. The output from this type of pump is influenced by pressure. This pump is ideal for delivering large volumes of liquid at low pressures. A key component of the centrifugal pump is the throttling valve. A manual throttling valve on the main output line is essential for the accurate operation of the centrifugal pump. The use of herbicides has replaced much of the mechanical tillage done formerly. Chemical application is done with attachments to tillage machines and seeders or with single-purpose chemical application.

Data Collection, Analysis:-

Basic Components of Sprayer:-

Parts of a sprayer pump (Fig. 1) are as follows:

Pump:- A pump is a piece of equipment used to move fluids, such as liquids or slurries, or gases from one place to another.

Tank:- It is the storage place of chemical solution. It is made up of PVC, Brass, etc.

Agitator:- It is the devices which stirs the solution and maintain the contents in homogenous state.

Air chamber:- In a reciprocate type pump, an air chamber is provided on the release line of the pump to level out the pulsations of the pump and thus given that an invariable nozzle pressure.

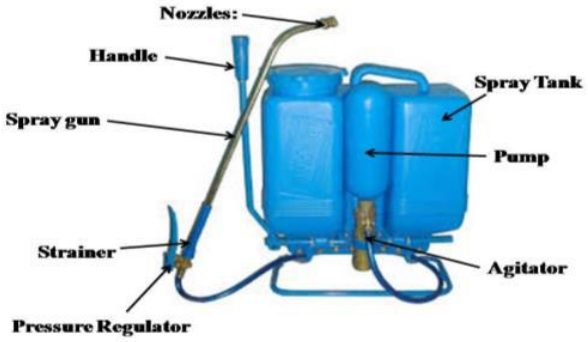

Fig. 1:- Components of sprayer pump

Pressure gauge:-
It is a dial gauge which shows the pressure at which the liquid is delivering from the pump.

Pressure regulator:-
The pressure regulator use for some important functions. It is the means of adjust the pressure is necessary for any spray job within the pressure choice of the pump.

Strainer:-
It is a little circular plastic ring with nylon wire mesh to filter any dust element coming with the chemical solution it is included in the suction line connecting the chemical tank and the check valves.

Nozzles:-
It is the part which pull the fluid in to fine droplet. Mechanization of spray fluid is usually achieved by releasing the liquid through lips called nozzle under pressure.

Market Study:-
Nature of Market:-

- Market size: Approximately rupees 6000 million annually
- Approximately Annual Growth: 10%
- Price Range:
  - Power Spray: Approximately Rupees 3000-30,000
  - Manual spray: approximately Rupees 600-1800
  - Chinese Power spray: Approximately Rupees 2700
- High volume low profit market
- Highly price sensitive market
- Bundling of services with pesticide companies is done for branding
- Land holding does not matter

User Study:-
While interacting with users information were collected. During the interaction questions were asked to users to know what the user wants and what sort of problems they are facing while carrying out their routine work.

User Findings:-

- Most of the farmers are using knapsack motorized sprayers
- The product and maintenance cost were so high and also fuel were required to run the motor
- For electrically operated sprayers life span is less and sometime process will not complete due to battery storage and also the cost is little high
- Knapsack hand operated sprayers have less operating cost and the products cost is also not high but the effect of the product on him human health is more because it hold on backbone and was operated by hand continually.

- Sprayers have operated by solar battery ever costly are not affordable by farmers.

Quality Function Deployment (QFD):-
QFD has been developed for converting customer voice into technical voice. Attributes are prioritized and ratings are given in order to define the relations between them are as shown in Table 1. The Product Design Specification (PDS) is tabulated in Table 2.

Table 1:- QFD

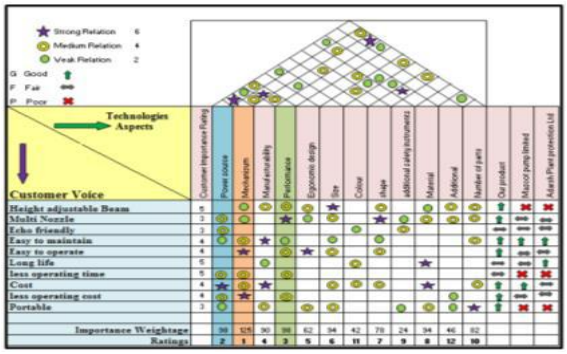

Table 2:- PDS

Sl. No	Factors	Specifications
1	Performance (technical specifications)	Tank capacity :25ltr Pump : Piston Pump Working Pressure : 2-3bar Max pressure : 5bar Nozzle type :Multi nozzle Power source: Mechanical power
2	Environment	Easy installation, easy to detach & attach, lightweight & washable
3	Life Span	5-8 years
4	Maintenance	Once in season
5	Target Customers	Indian Middle Class Farmers
6	Major Materials Used	Base Frame :Steel Roads , Tank: HDPE Plastics,
7	Process	Design , Detailing, Fabrication & validation
8	Major Dimensions	(WXLXH) mm
9	Weight	20-30kg
10	Ergonomics	Gripping, Reach For control and accessibility
11	Colour	Ecofriendly colour
12	Cost	Approximate 5000/-Rs
13	Transport	Easy to transport (portable)
14	Appearance	Good appearance , easy to use
15	Type	Portable
16	Safety	Safe and smooth operating

Concept Generation And Selection:-

Concept Generation;-
Five concepts were generated considering various factors which meet the PDS like functionality, safety and cost. Final concept was selected and the working prototype model was build.

Push Type Sprayer:-
Features of this concept like hand operated hydraulic pump and lever is connected to crack by link. The existing tank (10-16 liters) focusing on new mechanism is to be used as shown in Fig. 2.

Fig. 2:- Push Type Sprayer

Tank Carrying Sprayer:-

In this concept to solve the existing problem like back ache and shoulder pain. The height adjustable stand with two support wheel to was designed to pull forward easily as shown in Fig 3.

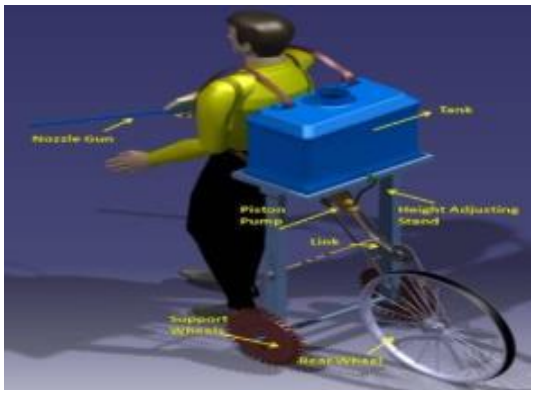

Fig. 3:- Tank Carrying Sprayer

Sprayer With Out Stand:-

The frame design is to changed increase aesthetic look of the product and adjustable height support stand as shown in Fig. 4.

Fig. 4:- Sprayer With Out Stand

Multi Nozzle Operated Sprayer:-

Concept 4 look like concept 3 but for easy movement and support two small wheels were included.It is easy to spray for any height crops because Adjustable height support stand will included as shown in Fig. 5. The product can spray pesticide over multiple rows of plants in one pass there by reducing manual effort.

Fig. 5:- Multi Nozzle Operated Sprayer

Concept Selection:-

Weighted ranking method was used (Table 3) to select the final concept for further development of the product.

Table 3;- Concept selection chart

Design Factor	Concept 1	Concept 2	Concept 3	Concept 4	Concept 5
Safety	2	3	3	3	**4**
Functionality	3	4	3.5	4	**4**
Weight	4	2.5	3	3.5	**3.5**
Mechanism	2	3	3	3	**4**
Cost	2.5	2.5	2	3.5	**4**
Total	13.5	15	14.5	14	**15.5**
Ranking	5	2	3	4	**1**

Concept 4was selected for further development of the product and this will meet the PDS.

Multi Nozzle Operated Sprayer:-

Project Concept:-

To overcome all the issues faced during spraying methods, a model running without any fuel and also easy to operate for a user was designed. In this model 1 find that a cam mounted on rear shaft which will actuate piston inside cylinder was used Fig. 6.

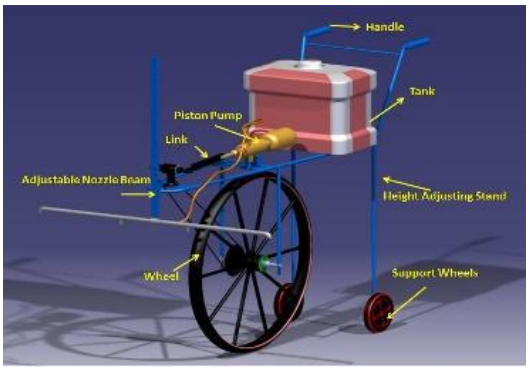

Fig. 6:- Multi Nozzle Operated Sprayer

Final Concept Detailing:-

Piston and Cylinder assembly:-

Cylinders made by brass were selected with Rubber pistons, because they are easily available and economical and also technically, they are easy in operation.

Tank design:-

Tank carry more fluid with less weight. A tank with 25 liter capacity is taken.

Nozzles:-

The standard nozzle selected are same as that are used in agricultural sprayers

Handle design:-

While designing the hand the ergonomic data is also considered.

Height Adjustable Support Stand:-

The Indian ergonomic data to adjust the height of the handle, so that users give more strength and support to the frame is also considered.

Working of Final Concept:-

When one push the sprayer trolley, work done by the wheels get transmitted first to cam and then to follower link, due to which the piston reciprocate and starts building pressure. Power is getting transferred to piston, at the same time a coulter come into action and its flaps starts their function. As the time passes, a strong pressure gets developed inside the cylinder as accumulator helps it in doing the process. As the pressure gets developed, nozzles start acting and they initiate spraying. During this time, a connecting link from coulter also moves its flaps rapidly and soil is taken to the roots of plants. Fig 7 shows the final working model.

Fig. 7:- Final working model

Validation:-

Validation of Final Working Model:-

Product were given to farmers and they fill the pesticides tank with clean water and moving the full unit pesticides will spray on the plant as shown in Fig. 8.

Fig. 8:- Validations

Validation Result:-

Follow these steps to calibrate working model:

- Measure the spryer width of the nozzle
- Measure the nozzle output in liters over one minute.
- The Sprayer volume can be calculated by following formula:

Nozzle output (L/min) X10, 000
Sprayer width (m) X Walking Speed (m/min)

Nozzle Output in 1min	=	0.4 litre (Avg)
Sprayer width	=	1m
Walking speed	=	100m/min
Application rate (L/hr)	=	0.4X10, 000/100
	=	4000/100
	=	40L/hr

Conclusion:-

No design is ever perfect for all the time; design needs to be changed as per the needs and wants of users. Inputs for new product development and or design improvements are obtained from the user's feedback and product evaluation with respect to user requirements. The major outcome from this effort of new product development is concluded below:

- Working prototype of the mobile pesticide sprayer was designed and developed
- The pesticide sprayer reduces back ache and shoulder pain while using the product
- The cost of the product can be brought down if mass production can be considered.
- The product can spray pesticide over multiple rows of plants in one pass there by reducing manual effort.
- The concepts were analyzed with the viewers and feedback was obtained where a final concept was selected and it was redesigned to suit the user requirements.

References:-

1. Sudduth K.A., Borgelt S.C., Hou J., (1995) Performance of a chemical injection sprayer system, Applied Engineering in Agriculture, 11(3), pp. 343-348.
2. Way T.R., Von Bargen K., Grisso R.D., Bashford L.L., (1992) Simulation of chemical application accuracy for injection sprayers. Transactions of the ASAE, 35(4), pp. 1141-1149.
3. Philip J. Sammons, Tomonari Furukawa, Andrew Bulgin, (2005) Autonomous Pesticide Spraying Robot for use in a Greenhouse, The University of New South Wales, Australia.