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DESIGN AND DEVELOPMENT OF WHEEL SPRAY PUMP

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***Abstract* - India is set to be an agricultural based country and approximately 75% of the peoples are dependent on farming directly or indirectly, 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, we use many different spraying technologies involving use of energy like electrical energy, solar energy, and chemical energy of fuels. This fact makes us 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 these problems many different type of sprayers has been introduced in the market, but these devices do not meet the above problems or demands of the farmers. To solve these difficulties develop 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. This wheel operated pesticide spray equipment consumes less time and achieves uniform nozzle pressure; we used crank mechanism with piston pump, which is driven by the wheel.**

This paper aims at developing a low cost mechanically operated sprayer pump for Indian middle scale farmers, Study the literature review, user study and market study. Based on literature and market study develop QFD and PDS char, and generate the many concepts. A final concept has been select for further development and detailing. A full scale working model has been fabricated for design validation. The device has been validated with the user group and got good feedback from the user.

Keywords: Usability, Functionality, Ergonomics, Wheel Driven, Multi Nozzle

I.INTRODUCTION

Farming is the backbone of Indian economy. 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 electrical 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, herbicides or fungicides, we must be sure it is 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.

1.1 Method and Methodology

- Data collection will 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 will be generated prioritizing the features in the QFD
- Concepts will 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 will be made with detailed features and feedback were collected

II LITERATURE SURVEY

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 [1]. Development of a direct nozzle injection system that overcame the concentration variation problems reported by previous researchers [2]. 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.

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 [3]. 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.

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.

III DATA COLLECTION, ANALYSIS

3.1 Basic Components of Sprayer

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 full the fluid in to fine droplet. Mechanization of spray fluid is usually achieved by releasing the liquid through lips called nozzle under pressure.

3.2 *Market Study*

Nature of Market:

- Market size: Approximately rupees 6000 million annually
- Approximately Annual Growth: 10%
- Price Range:
  - Power Spray: Approximately Rupees 300030,000
  - Manual spray: approximately Rupees 6001800
  - 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

3.3 User Study

Information was collected while interacting with users. During the interaction questions were asked to users, these one on one interviews helps in to know what does the user wants and what sort problems they are facing while carrying out their routine day to day work, during the one on one interviews.

3.3.1 User Findings

- Most of the farmers they are using knapsack motorized sprayers
- The product and maintenance cost so high and also fuel required to run the motor
- Electrically operated sprayers life span is less and sometime process will not complete due to battery empty and also cost is little high
- Knapsack hand operated sprayers have less operating cost and product cost is also not high but effect of the product of human health is more because it hold on backbone and operated by hand continues

- Solar battery operated sprayers have cost to high farmers are not affordable

3.4 Quality Function Deployment (QFD)

QFD has been developed 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 I.

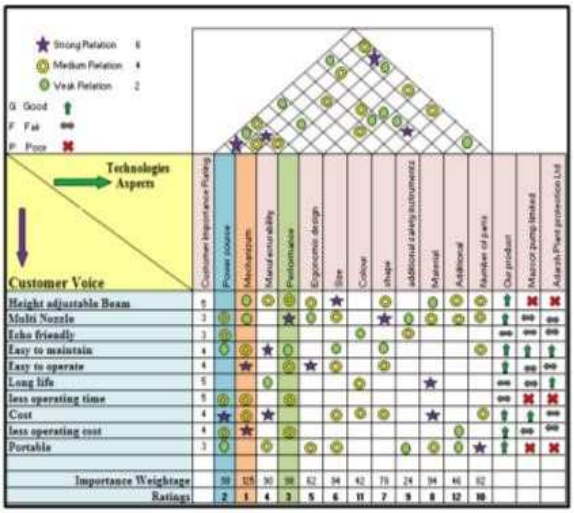

Fig. 2 QFD

Table. I PDS

Sl. No	Factors	Specifications
1	Performance (technical specifications)	Tank capacity :25ltr Pump : Piston Pump Working Pressure : 2-3bar Max pressure : 10bar 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) 380X1065X1140mm
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

IV CONCEPT GENERATION AND SELECTION

4.1 Concept Generation

Five concepts were generated considering various factors which meets the PDS like functionality, safety and cost. Final concept selected and build the working prototype model.

4.1.1 Concept 1

Features of this concept like hand operated hydraulic pump and lever is connected to crack by link. Use the existing tank (10-16 liters) focusing on new mechanism

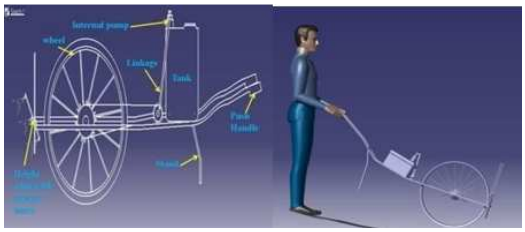

Fig. 3 Concept 1

4.1.2 Concept 2

In this concept to solve the existing problem like back ache and shoulder pain. We design the height adjustable stand with two support wheel to easily pull forward as shown in Fig 4.

4.1.3 Concept 3

Concept 3 has pushing type frame design. Sprayer pump tank capacity is increase to 30 liters cover the more area of land and save the time as shown in Fig. 5.

4.1.4 Concept 4

Concept 4 has like concept 3 but change frame design to increase aesthetic look of the product and adjustable height support stand as shown in Fig. 6.

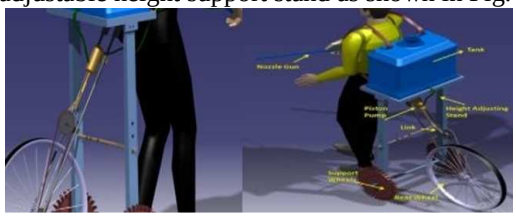

Fig. 4 Concept 2

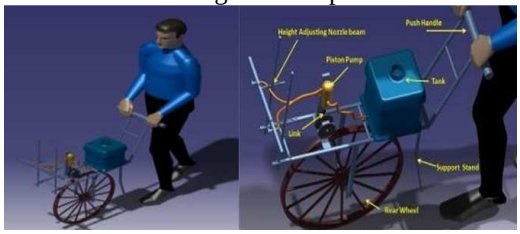

Fig. 5 Concept3

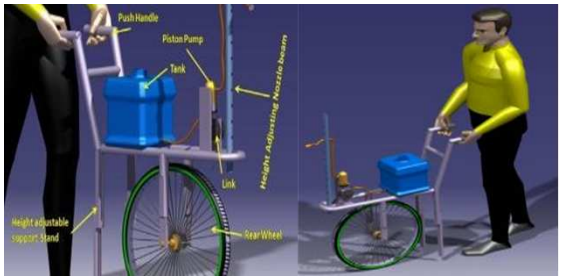

Fig. 6 Concept4

4.1.5 Concept 5

Concept 5 has look like concept 4 but for easy movement and support two small wheels included. Easy to spray for any height crops because Adjustable height support stand will included as shown in Fig. 6. The product can spray pesticide over multiple rows of plants in one pass there by reducing manual effort.

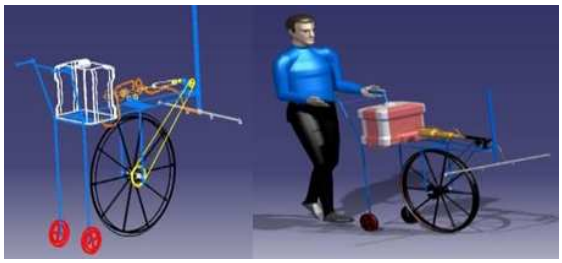

Fig. 7 Concept5

4.2 Concept Selection

Weighted ranking method was used (Fig. 8) to select the final concept for further development of the product.

Concept 5 has selected for further development of the product and this will meet the PDS.

V FINAL CONCEPT DETAILING

5.1 Project Concept

To overcome from all issues faced during spraying methods, we have designed a model running without any fuel and also easy to operate for a user. In this model I find that we have simply used a cam mounted on rear shaft which will actuate piston inside cylinder (Fig. 9).

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**

Fig. 8 Concept selection chart

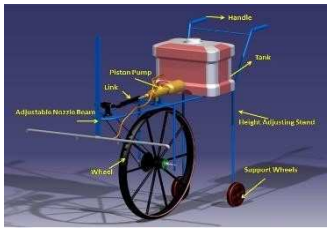

Fig. 9 Final concept

5.1.1 Final Concept Detailing

Piston and Cylinder assembly: We have selected brass made cylinders with Rubber pistons, because they are easily available and economical. Along with this, technically, they are easy in operation.

Tank design: Tank carry more fluid as it can be along with its self-weight as less as possible. We have taken a tank which is 25 liter capacity.

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

Handle design: While designing the hand we considered the ergonomic data.

Height Adjustable Support Stand: we considered the Indian ergonomic data to adjust the height of the handle, so that users give more strength and support to the frame.

5.1.2 Working of Final Concept

When we 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 starting their function. As the time passes, a strong pressure gets developed inside 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 8 shows the final working model.

The main aim of this paper is to analysis of circularity and taper angle in abrasive water jet machining for Inconel 825. The following conclusions are made

- The optimum input setting for minimum circularity and minimum taper angle was arrived using grey relational analysis. The optimum machining parameters obtained has water pressure 3800 bar, standoff distance 2mm, abrasive flow rate 400 mg/min.
- The minimum circularity is obtained as 0.977 mm for the experimental run 2.
- The minimum taper angle calculated as 1.3748° for the experimental run 15.
- The future study is based on the SEM for topography analysis.

VI VALIDATION

6.1 Validation of final Working Model

Product given to farmers some days they fill the pesticides with clean water and moving the full unit pesticides will spray on the plant as shown in Fig. 11.

6.2 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

Fig. 10 Final Woking Model

Fig. 11 Validation

VII 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 is 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.

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