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Design & Development of Agriculture Sprayer Vehicle with Solid Fertilizer

Prof. R.B.Mali[1], Shubham Gunjal[2], Ajinkya Gaikwad[3], Prajwal Jathar[4],Nikhil Mali
1 (Asst. Prof. Department of Mechanical Engineering NBNSSOE, PUNE.)
2, 3, 4, 5(Student of Mechanical Department NBNSSOE, PUNE.)
Shubhamg6699@gmail.com

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Abstract: *Majority of the sprayer pumps available in market are back mounted, hand pumps that are used to spray pesticides. Pesticide spray pump have to be pumped manually and then carried on the back for spraying in the fields. Agriculture sprayer vehicle operates the pump automatically as it moves, pump is mounted on vehicle so no stress to operator, very low cost. The pumping mechanism is connected to the rear wheel shaft through a gear train. Thus motion of the wheel is converted into automatic pumping of the pumping system. Earlier designs were wither top mounted piston handle pumps or side mounted handle piston Pumps. Both of them are to be carried on the back. Thus the spraying pressure is developed only when the handle is pumped. This causes fatigue and makes the operator tired. For spraying action, the pump is to be continuously pumped by hand to develop sprayer pressure inside the tank, so also the pump with the filled liquid is heavy and has to be carried on the back, hence a simple system that pumps fluid and carries the pump on a vehicle so that operator does not have to carry the pump is needed. Crank link operated pump works automatically when vehicle is moved. The pumping mechanism is connected to the rear wheel shaft through a gear train. Thus motion of the wheel is converted into automatic pumping of the pumping system. Pump is carried on the moving vehicle, the pump is provided with two additional mechanism namely to uniformly spray the pesticides on the crop and secondly a solid fertilizer sprayer with the help of wheel motion. Project work involves the design development analysis of components, fabrication of the unit and testing the equipment to find performance parameters.*
Keywords: *Cost effective equipment, Solid fertilizer sprayer, Liquid fertilizer sprayer, Sprayer Vehicle, Solid and Liquid fertilizer sprayer, Economic*

I. Introduction

India is a country whose economy is mainly based on agriculture. Most of the people of our country are farmers. Main aim of this paper is to reduce human efforts and also support small scale farmers who cannot afford expensive equipments for farming. Main purpose of sprayer is to spray pesticides and fertilizer. But this proposed solution can perform two operation at time and is cost effective. Basically, many farmers in India uses traditional method for farming. This will not satisfy need of energy requirement of the farming as compared to other countries in the world. So we are thinking that human and animal efforts can be replaced by some advance mechanization which will be suitable for small scale farmer from economical and effort point of view.

Problem Statement and Solution

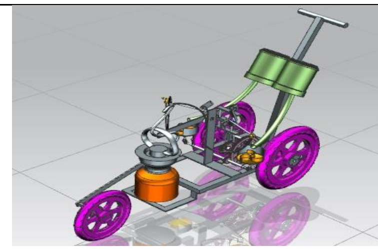
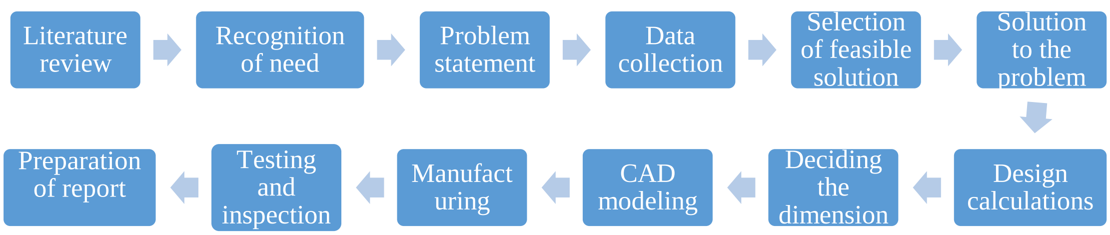
Problem Statement	Solution
Earlier operated back mounted agriculture sprayer pump are less efficient. The area covered by them is also less. By using tractor sprayer there is significant increase in soil pollution and also reduces the productivity of the soil. This problem statement also focuses on social impact. This model requires less hard work as compared to back mounted sprayer and less cost as compared to tractor sprayer. The problem focuses on welfare of farmers and bringing social impact.	 Figure 1: Proposed Solution

Table 1: Problem Statement and Solution

Objectives

1. Design of agriculture sprayer vehicle with motive power from the wheel drive
2. Design of agriculture dispenser with motive power from the wheel drive
3. Fabrication of agriculture sprayer vehicle with fertilizer dispenser.
4. Testing of device to find performance characteristics.

Methodology



II. Literature Review

Sr. No.	Author Name	Work done by Author
1.	**Chaudhar et al.**	Developed a fertilizer spreader that uses impeller type of disc for dropping solid fertilizer over agricultural land efficiently.
2.	**Narode et al.**	Developed a manually operated fertilizer spreader. The technique has three wheel arrangement, one rear mounted and two forepart wheels. The fertilizer is impelled by the front arrangement of wheels.
3.	**Ramchandra et al.**	Developed a fertilizer broadcaster at sowing time to uniformly distribute the fertilizer over entire field.
4.	**Deshpande et al.**	Designed and developed manually operated fertilizer spreader. The impeller type of disc is used for spreading fertilizer. The method consist of two wheels which are used to spread fertilizer. It consists of vessel used to store fertilizer and also pass control mechanism.

5.	**Hao et al.**	Developed a system that optimizes design of granular compound fertilizer and outer groove fertilizer spreader. Also build a 3D CAD model.

Table 2: Summary of Literature Survey

Literature Gap

The literature review shows that the existing fertilizer spreading equipment have some limitations. Most equipment are heavy and having wheels attached for pushing. Even though these equipment move effortlessly on normal grounds, it cannot be pushed easily in the farms with uneven and wet surfaces. This increases the effort of user and also increases fatigue. In addition to this, many equipment use turbines or blades to spread the fertilizer, which are suitable for even spreading in the land. But to ensure effectiveness the fertilizers need to be spread near the roots of individual plant. Normal equipment are unable to fulfill this requirement. In order to overcome these limitations, it is proposed to develop manually operated device for spreading solid fertilizer.

III. Design Calculations

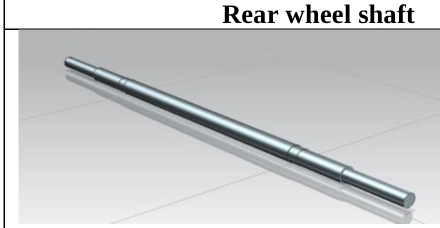
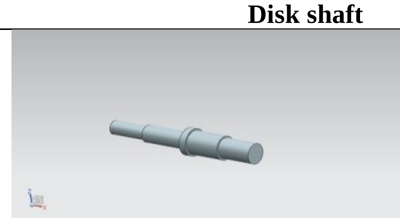
Rear wheel shaft	**Disk shaft**
 **Material:EN24** Figure 2: Wheel shaft	 **Material:EN24** Figure3: Disk shaft
By using ASME code of design ; Values of syt and sult are taken from properties of material EN24 Torque = 1.12 N-m Fs_{all} = syt*0.30 = 0.30 x 600=180 N/mm^2 Fs_{all} = Sult *0.18= 0.18 x 720= 130 N/mm^2 Taking lowest of the above values ; fs_{all} = 130 N/mm^2 Dimples are provided for locking purpose; Above value is reduced by 25%. fs_{all} = 130*0.75= 97.5 N/mm^2 Pure torsional load is considered for designing shaft; Tdesign= $\Pi * d^{3*} fs_{all}/16$ d = 8.75 mm selecting minimum diameter of shaft = 12 mm as the shaft end carrying the wheel which has a pilot bore of 12mm.	Using ASME code of design ; Values of syt and sult are taken from properties of material EN24 Torque = 0.3 N-m Fs_{all} = syt *0.30= 0.30 x 600=180 N/mm^2 Fs_{all} = Sult*0.18 = 0.18 x 720= 130 N/mm^2 Taking lowest of the above values ; Dimples are provided for locking purpose; Above value is reduced by 25%. fs_{all} = 130*0.75= 97.5 N/mm^2 Considering pure torsional load; Tdesign= $\Pi * d^3 * fs_{all}/16$ d = 3.3 mm selecting minimum diameter of shaft = 8 mm as the shaft end carrying the bevel gear which has a pilot bore of 8mm.

Table 3: Calculations of wheel and disk shaft

Gear and Pinion	Lewis Strength equation
 **Material:Nylon66** Figure 4: Spur gear Maximum load =Maximum torque / Radius of gear No of gear teeth = 120	WT = Sbym Where ; $Y= 0.484 - \frac{2.86}{Z}$ $Yp = 0.484 - \frac{2.86}{60} = 0.44$ Syp = 34.91 As Syp < Sys $\Rightarrow$ Pinion is found to be weaker from above calculation W_T = (Syp) x m x b=34.91 x m x 10m

No of pinion teeth = 60 Module = 1.275mm Load=200 N b = 10 m Spur gear and pinion's material selection= Nylon-66 Sult pinion =Sult gear= 300 N/mm^2 Service factor of Gear and Pinion (Cs) = 1.5 The entire tooth load is shared by the gear and pinion arrangement where as pinion has 60 teeth and gear has 120 teeth $\Rightarrow$Pt = (Cs x W) = 1.5 x 200 = 300 N. Peff = 300 N --------(A)	W_T= 349.1 m^2----------(B) Equation (A) & (B) 349 m^2 =300 $\Rightarrow$m=0.93mm Standard module selected from above calculations Module = 1.275mm.

Table 4: Calculation of gear and pinion

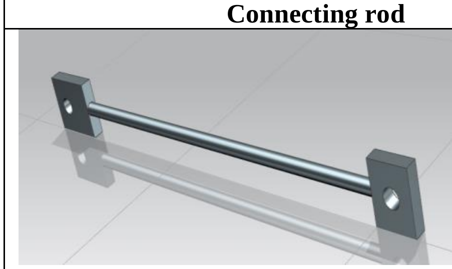
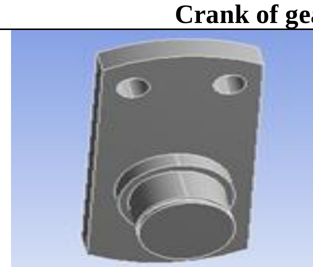
Connecting rod	**Crank of gear disk hub**
 **Material:C45** Figure 5: Connecting rod	 **Material:EN9** Figure 6: Crank
Syt = 480 N/mm^2 Sult = 600 N/mm^2 Values taken from ASME code design FORCE ANALYSIS: Torque = Force x radius Thus , Force = Torque / radius = 8100 /25= 324 N	Crank arm is subjected to direct shear failure owing to the load of the Gear action, Crank arm is having a circular section of 14 mm diameter subjected to direct shear Cam force is given by relation (Cf) = T/r = 1.12 x 1000 / 35 As the eccentricity radius of 35 mm is considered for the pump rocking action (Cf) = 32 N Shear stress = shear force / area $\Rightarrow$ fs_{act} = $(32 / \pi \times 14^2 /4)$ N/mm^2 =0.207 N/mm^2 As**; $fs_{act} < fs_{all} \Rightarrow$ Crank is safe**

Table 5: Calculation of Connecting rod and Crank

CAD Model

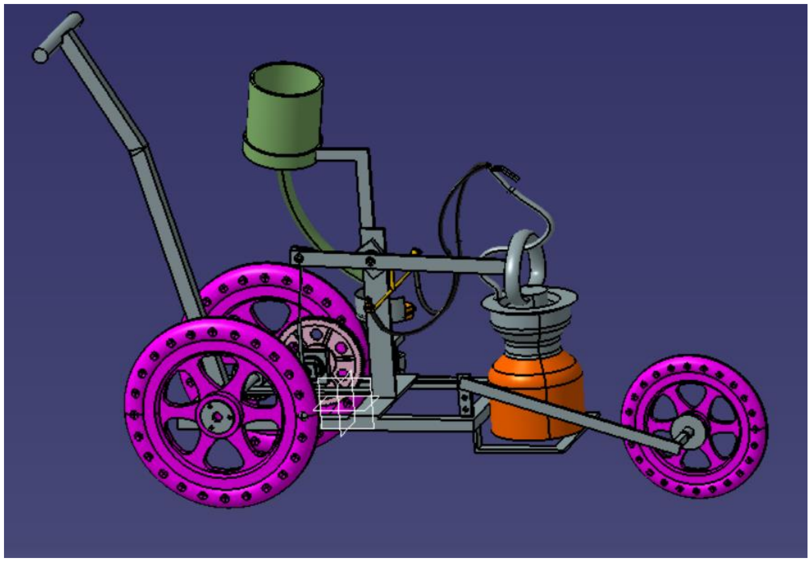


Figure 7: CAD model of setup

Observation Results:

Sr. No.	Walking Speed	Area/Tank for liquid fertilizer	Time for liquid fertilizer	Area/Tank for dispenser
01	3 kmph	0.48 acres	21 min	0.18 acres
02	3.5 kmph	0.56 acres	18 min	0.20 acres
03	4 kmph	0.68 acres	16min	0.25 acres
04	4.5 kmph	0.76 acres	14 min	0.27 acres

Table 6: Result of liquid and solid fertilizer spray over area

For Liquid Fertilizer

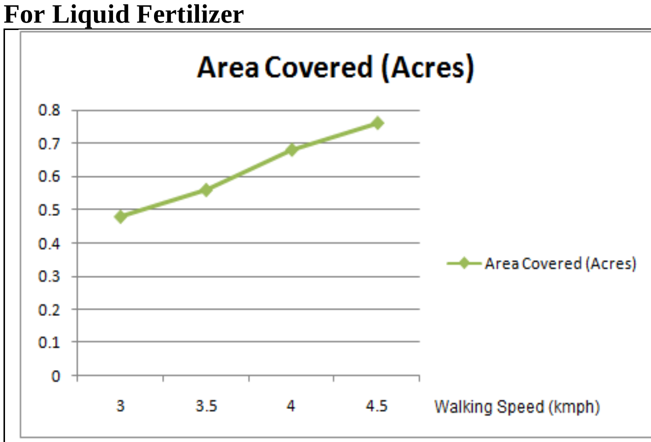


Fig.8: Graph of Area Covered by Sprayer Vs Walking Speed

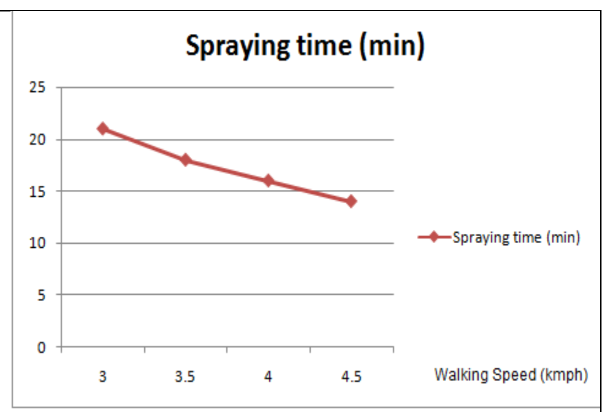


Fig.9: Graph of Time of Spraying Vs Walking Speed

Table 7: Graphical representation for liquid fertilizer

For Solid Fertilizer

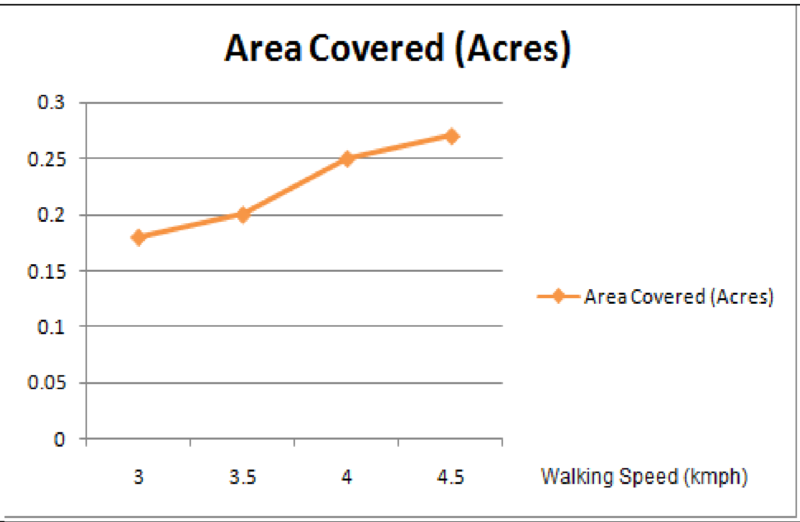


Figure 10: Graph of Walking speed Vs Area covered / tank

Comparison between old and new pump

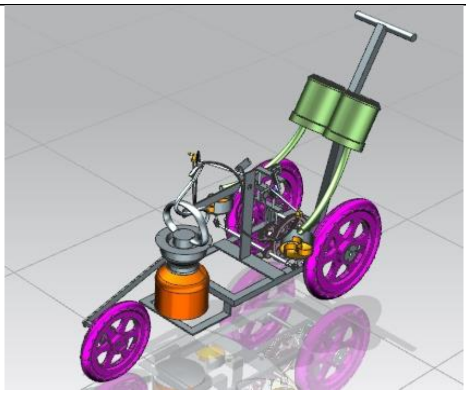
 Figure 11: Old design of pump	 Figure 12: New design of pump
1. Cost of pump is low. 2. It can only spray liquid fertilizer.	1. Initial cost is little high as compared to old pump. 2. Can spray both fertilizer at same time. 3. Reduces human efforts.

Table 8: Comparison between old and new model

IV. Conclusion and Future Scope

Conclusions:

Many spraying devices are present in market today. But the back mounted pump increases the hard work. The cost of tractor sprayer is high, which cannot be afforded by small scale farmers. The design and model created focuses on reducing human efforts. This solution is not so expensive also. Unlike tractor fertilizer there is no wastage of fertilizer and pesticides. There is no decrease in productivity of land. Comparative study of old and created model shows that this solution is efficient and covers more land than back mounted sprayer.

Future scope

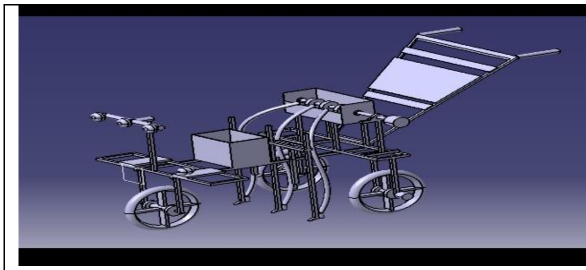
 Figure 13: Future Modification in model	Further work can be done for adding more arrangements like routing arrangement, weeder arrangement, and seed sowing arrangement. This work can be implemented for better results. Future model can be more helpful for small scale farmers and more efficient. This solution believes on creating social impact.

Table 10: Future Scope

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