

# Design Analysis and Performance Evaluation of Auto-Pitch Line Sprayer for Pesticide Spraying and Rotatable USB Camera for Horticulture Crops

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**ABSTRACT:** Pesticide spraying is an important part of agriculture it is necessary for pest control and proper growth and disease free nature of crops. But nowadays the excess use of pesticide is tending to increase pollution and leading to drug-resistant pest. The excess use of pesticide leads to economic loss and also soil, water and air pollution. Presently two methods of pesticide spraying are in use one is manual method and other using the tractor mounted sprayer. Either method is inefficient as the manual methods are time-consuming and labours intensive whereas the tractor mounted sprayer method is costly and waste a lot of pesticides and leads to pollution. Thus the project work proposes an effective method of pitch line spraying i.e. spraying only on the plant by use of an effective bird wing spray thus limited use of pesticide, automation will reduce the time required and labour required for the operation. Lesser pesticide use will help pollution reduction. The rotatable camera will help detect disease on the crop in time and thus the corrective action can be taken. Project work includes the design development manufacturing and testing of the automated sprayer vehicle. The paper presents a brief overview of the design and analysis of the critical components like the frame plate, rotatable Camera drum and drives shaft. The components have been developed using Unigraphics Nx8 and the structural analysis has been done using Ansys Workbench 16.0. The testing was carried out on the machine to determine the experimental pitch, wetted area per charge and the savings in pesticide consumption.

## I. INTRODUCTION

A sprayer is a device used to spray a liquid. In agriculture, a sprayer is a piece of equipment that sprays nozzles to apply herbicides, pesticides, and fertilizers to agricultural crops. Sprayers range in size from man-portable units (typical backpacks with spray guns) to self-propelled units similar to tractors, with boom mounts of 60–151 feet in length [1].

As we know that the India is an agriculture-based country and comprising 70% of people whose busy in doing farming and its relating work. Agriculture is required to be boomed to enhance the Gross Domestic Product (GDP) of the country by improving productivity. The productivity of the crops can be increased with the help of pest control. Pesticide spraying is needy procedure during crop cultivation so the presenting idea is dealing through designing of fabricating a pesticide sprayer which will be only useful but also affordable to the farmers that will tend to increase the crop productivity. In order to reduce the harm to the environment and people the research and development of plant protecting machine focus on improving the mechanical work efficiency and the effective availability of pesticide. This option has agreed among people all over the world, especially in the developed country. Agriculture is an important sector of the Indian economy, accounting for 14 % of the nation's GDP[3]. India is set to be an agricultural based country approximately 70 % of the population of India is dependent on agriculture directly or indirectly. Our farmers are using the same methods and equipment for the ages. Indian agriculture is having large diversity because of eliminating and extensive sector involving a large number of acres. It has been one of the remarkable success stories of the post-independence era through the association of Green Revolution technologies. Generally, mechanization of small forms are very difficult and non-affordable but the Japanese make it happens. One of the most common forms of pesticides application, especially in conventional agriculture, is the use of mechanical sprayers. Hydraulic sprayers consist of a tank, a pump, a lance (for single nozzles) or boom, and a nozzle (or multiple nozzles). Sprayers change the pesticide formulation by altering the contents % of water mixture and chemical fertilizer that tends to changes in the size of the droplets may be large size rain of drops or tiny almost like invisible particles [4]. This conversion is accomplished by forcing the spray mixture through a spray nozzle under pressure. The droplets size can be changed by using different nozzles or by changing pressure under which it is forced, large sized droplets have the advantage of being less sensitive or exposed to pesticide drift but required more amount of water per unit area of land covered. Due

to static electricity, small droplets are able to maximize contact with a target organism, but very still conditions are required. The project aim is to remove the backpack and foot spraying techniques, eliminate the human efforts, to decrease labour cost by advancing the spraying method and constant flow of droplets and using non-conventional sources for charging the batteries [7]

Types:

- 1.Backpack/knapsack
- 2.Foot Garden Hand compression Power Stirrup.

### Problem statement



Fig. no. 1- Backpack/knapsack methods

Manually operated sprayers are slow and labour intensive so lots of time and cost is utilized in sprayer ...more over the pesticide chemicals are injurious and hazardous to health[8].  
Secondly



Fig.no. 2- Foot Garden Hand compression Power Stirrup

- Tractor mounted power sprayers require less time and effort but ...
- Require more pesticide ...Cost of spraying increases
- Pesticide is wasted more
- High Air / Water & Soil pollution
- Hazardous to health even if your breathe / eat / drink pesticide

## II. DESIGN AND ANALYSIS

### A) Design & analysis of robot chassis.

Material: Aluminium

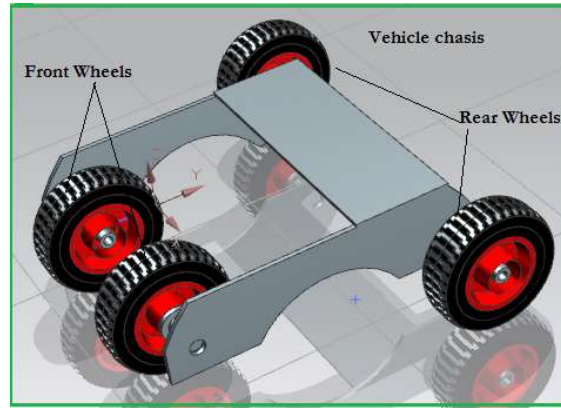


Fig.no.3- robot chassis

Check for bending failure of chassis

$$F_b = M/Z = M / 1/6 tb^2$$

$$\Rightarrow f_{b_{act}} = 10.05 \text{ N/mm}^2$$

As  $f_{b_{act}}$  (Actual stress in frame) <  $f_{b_{all}}$  ; (allowable stress 60 Mpa) frame is safe.

- Analysis of frame under given system of loads

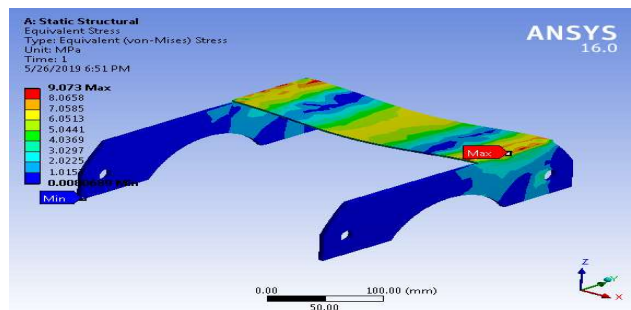


Fig.no.4 (a)-Stress analysis of robot chassis

The maximum von-mises stress is 9.073 Mpa

The maximum Von-mises stress is 9.073 Mpa which is fairly below the allowable value of stress hence the frame is safe.

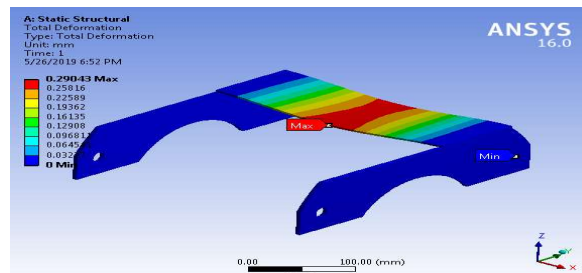


Fig.no.4 (b)- Deformation of robot chassis

The maximum deformation is 0.29 mm

The maximum deformation is 0.29 mm which is very negligible hence indicating again that the frame is safe.

Result & discussion for theoretical and analytical strength analysis of frame.

TABLE 1: RESULT & DISCUSSION

Part Name	Maximum theoretical stress (MPa)	Von-mises stress (MPa)	Maximum deformation Mm	Result
Frame	10.05	9.073	0.29	Safe

1. Maximum stress by the theoretical method and Von-mises stress are well below the allowable limit, hence the flywheel is safe.
2. Flywheel shows negligible deformation under the action of system of forces.

B)Design& Analysis of drive shaft

Material: Alloy steel (En24)

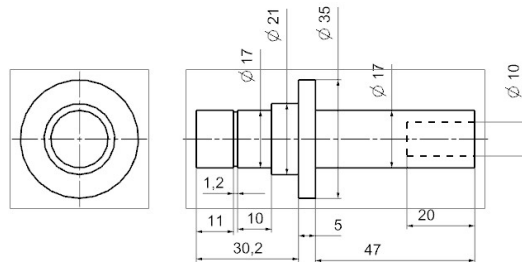


Fig.no.5-Design of drive shaft

Check for torsional shear failure of shaft

$$T_d = \frac{\pi}{16} \times f_{s_{act}} \times (D^4 - d^4) / D \Rightarrow f_{s_{act}} = 1.483181 \text{ Mpa}$$

As  $f_{s_{act}}$ (Actual stress in frame) <<  $f_{s_{all}}$  ; (**allowable stress 80 Mpa**) pressure plate is safe

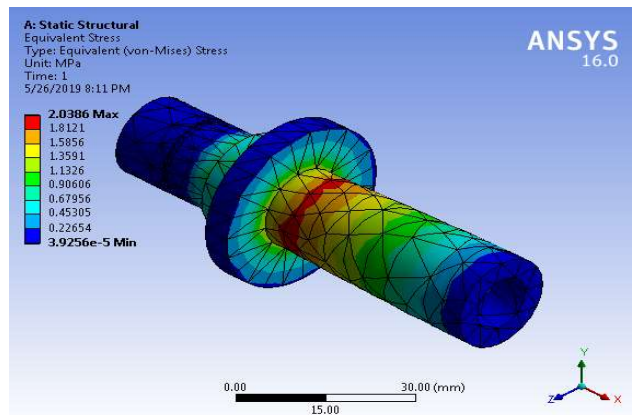


Fig.no.6 (a)-Stress analysis of drive shaft

The maximum Von-mises stress is 2.0037 MPa which is fairly below the allowable value of stress hence the shaft is safe.

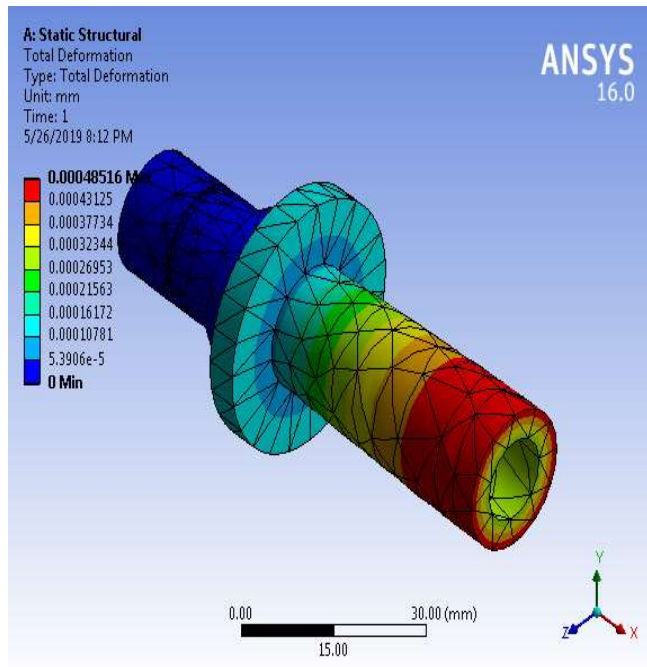


Fig.no.6 (b)-Deformation of drive shaft

The maximum deformation: 0.00048mm which is very negligible hence indicating again that the frame is safe.

TABLE 2: RESULT & DISCUSSION

Part Name	Maximum theoretical stress (MPa)	Von-mises stress (MPa)	Maximum deformation Mm	Result
Main shaft	<u>1.4875</u>	2.0037	0.00048	Safe

### III. TEST AND TRIAL



Fig.no.7-Experimental model of robot vehicle



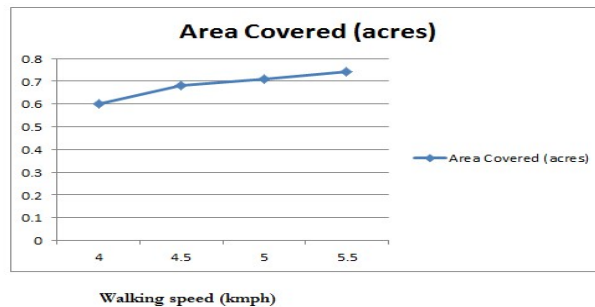
The present device is a replacement of the conventional manual sprayer where in the back-mounted engine is continuously running and the spraying activity is taken place irrespective of the pitch of the horticulture crop , which results into wastage hence through the comparative analysis through the test and trial the effectiveness of the new developed device is proven over the conventional one...the input parameters of walking speed are significance considering that the area covered by the spray is a function of the walking speed and is detrimental in deciding as to consumption of pesticide per unit area.

**A) Test and trial on Agriculture Sprayer**

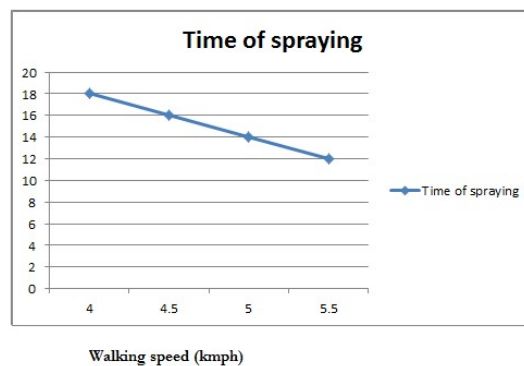
TABLE 3: RESULTS FOR CONVENTIONAL MANUAL SPRAYER MECHANISM:

Sr. No	Walking Speed	Area covered / tank	Time
01	04 kmph	0.6 acres	18 min
02	4.5 kmph	0.68 acres	16 min
03	5 kmph	0.71 acres	14 min
04	5.5 kmph	0.74 acres	12 min

Graph of Area Covered by sprayer Vs Walking speed



The area covered by the sprayer increases with the increase in walking speed as the pumping pressure increases fine droplets are produced which leads to lesser pesticide consumption as compared to low walking speed

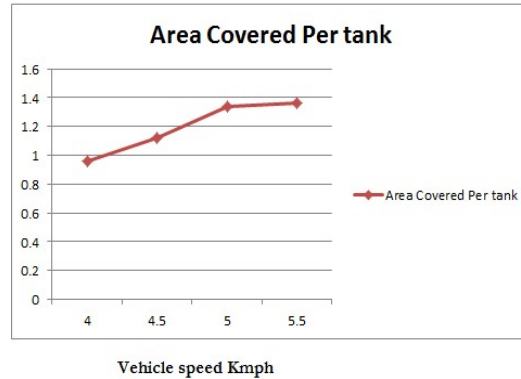


The time of spraying by the sprayer decreases with the increase in walking speed.

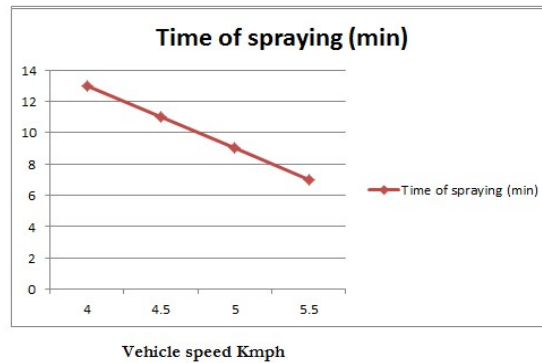
TABLE 4: RESULTS FOR AUTO PITCH LINE SPRAYER MECHANISM

Sr. No	Vehicle Speed	Area covered / tank	Time
01	04 kmph	0.96 acres	13 min
02	4.5 kmph	1.12 acres	11 min
03	05 kmph	1.34 acres	9 min
04	5.5 kmph	1.36 acres	7 min

Graph of Area Covered by Sprayer Vs Vehicle speed

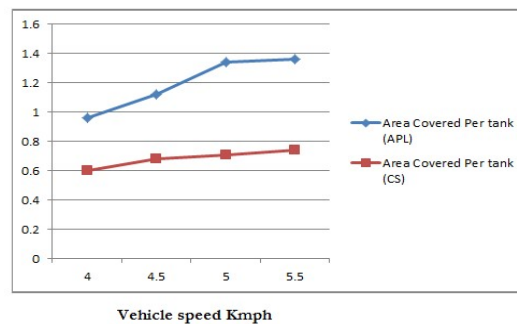


The area covered by the sprayer increases with the increase in vehicle speed as the auto pitch line sprayer saves the wastage of pesticide that is not sprayed between plants, leads to lesser pesticide consumption.

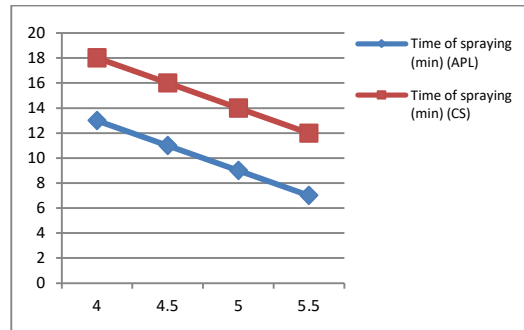


The time of spraying by the sprayer decreases with the increase in walking speed.

### B) Comparison graphs



From the comparison it is clear that the Auto pitch line sprayer has lesser pesticide consumption as it covers more area in the same volume of pesticide tank, thus it saves the farmer money on pesticide and also creates lesser soil, air And water pollution.



From the comparison it is clear that the Auto pitch line sprayer takes lesser time as fully automatic in operation.

#### IV. CONCLUSION

1. The of design of the Frame shows that the maximum stress induced calculated using the theoretical method as well as the analytical method is well below the allowable stress in the material of the part hence it is safe, so also deformation is negligible..
2. The design of the Driveshaft shows that the maximum stress induced calculated using the theoretical method as well as the analytical method is well below the allowable stress in the material of the part hence it is safe, so also deformation is negligible.
3. Testing revealed that from the comparison it is clear that the Auto pitch line sprayer has lesser pesticide consumption as it covers more area in the same volume of pesticide tank, thus it saves the farmer money on pesticide and also creates lesser soil, air and water pollution.
4. Testing revealed that the Auto pitch line sprayer takes lesser time as fully automatic in operation.

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