Design and analysis of aerially operated automatic sprayer for pesticides-grapes farming

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***Abstract*— Optimum requirement of pesticide spraying is required in order to protect the crops from various diseases. But in old technique there is no such parameter used for spraying pesticides. The old method of spraying pesticides is by using backpack type sprayer or by using mist blower along with tractor. But this old methods have their own limitations. Labours and time required for this old ways of spraying pesticides is more. Therefore in order to overcome this drawbacks we are proposing our aerially operated automatic sprayer and our system can be remotely operated through any electronic devices like android mobiles, wireless remote, etc.**

INTRODUCTION

Agriculture sector is the only field left away from automation. Automation is the branch of engineering that has evolved in every field in order to reduce the human efforts and work with higher efficiency in less stipulated time. Sowing of seeds, weed removing, spraying pesticides, and other works are carried by farmers manually which requires a lot of human labour. At present we are focusing our proposed robot for spraying pesticides techniques in grapes farming. The old methods of spraying pesticides in this farming are by using backpack type sprayer and air mist blower along with tractor. But the old methods of spraying pesticides have their own limitations.

Backpack type sprayer is very old conventional technique of spraying pesticides. This technique uses a pesticides holding tank on the shoulder and back of a man. The pesticides from tank is pumped using hydraulic principle. In this method of spraying both the hands of farmers are engaged therefore spraying pesticides with constant efficiency becomes difficult. The time required for the process is also more. Also the load of tank containing pesticides is near about 40 pounds which causes various back problems. The farmer gets in direct contact with pesticides which leads to further health issue problems. Therefore farmers have to use hand gloves and special clothing in order to prevent them from the attack of pesticides. Even there is no such parameter used to define the optimum requirement of pesticides therefore farmers on their own experience spray the amount of pesticides on the crops to prevent them from pest control and various diseases. Therefore sometimes less or more amount of pesticides is sprayed which is also harmful for the growth of the crops.

While the second way of spraying pesticides is by using air mist blower along with tractor. The whole setup is costlier, even some farmers doesn't find it affordable for using it for spraying pesticides. Even this method finds difficulties of spraying pesticides in extreme conditions like rainy season. There is also large amount of wastage of fuel used for the process. Air mist blower causes pesticides to get drift in air which travels to neighboring field which further causes damage to the growth of crops. So we are providing an engineering solution in order to overcome the drawbacks of spraying pesticides. As stated earlier we are at present applying this method of spraying pesticides for grapes farming. In which there will be the wire rope arrangement in between the two rows of trees. Over this wire rope our robot along with sprayers will be running and the control of robot is made using android mobile along with Bluetooth module HC-05. Conventionally the distance between two rows of trees is near about 6.5 feet for the entry of tractor but by using our solution we can decrease the distance between two rows of trees which will further increase the productivity level.

OBJECTIVES

1. Reliable to work under any conditions.
2. Decreases the cost of machine.
3. Eliminates direct contact of pesticides with farmers.
4. Cost effective.
5. Less number of labours required.
6. Spraying of pesticides can be done more efficiently.

SCOPE

1. Automatic and control of sowing seeds can be made Possible with some advancement in proposed device.
2. The proposed device can be used for spraying pesticides in pomegranate and grapes farming.
3. Angle of spray nozzle can be controlled for accurate spraying.

CONSTRUCTION AND WORKING PRINCIPLE

The device consists of the main body frame, battery, dc motor, nozzles, pipes, one wheel, two pulleys, Tank and dc Pump. This is the three-wheel drive device in which only one centered wheel is driven through by suitable RPM DC motor and other two pulley wheels are made to move freely over the wire rope. Frame is made up of Aluminum. It is 315 mm in length 140 mm in height and 4 mm in thickness. The nozzles are fitted to the pipes which are attached with the horizontal arm below the frame device as shown in fig. The tank containing pesticides is placed at one end. And the pesticides are carried from tank to sprayers with the help of pipes. The pump is placed nearby to tank in order to pump the pesticides. Arduino nano along with Bluetooth module HC-05 is used to move the device forward and backward with the help of any android mobile.

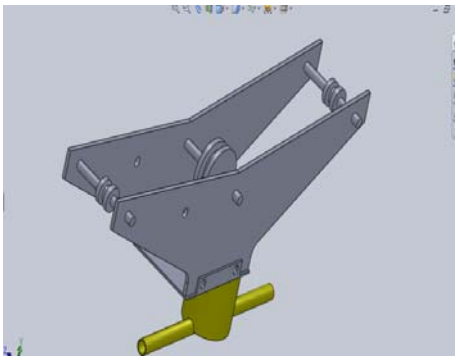


Fig. Cad model of device

Working:
The power source to run this device is through DC Battery. Battery is of 12V 9A. 150 RPM DC Motors which is directly attached to the wheel runs on the battery. The device is operated by mobile with the help of arduino nano along with Bluetooth module HC-05 for forward and reverse movement of motor where the output of motor is coupled to main wheel which rotates below the wire rope. This arrangement makes it possible to move forward and reverse over the wire rope. There is an PVC based frame structure as shown in fig. which consist of two parallel arms bent at an angle containing two spraying nozzle on individual arm of the structure for proper coverage of field. The pesticides to this spraying nozzle is supplied with the help of pump which carries the pesticides from tank to nozzle location with the help of flexible rubber hose. Wide range of Pressure and discharge can be obtained from the outlet of pump. Thus this arrangement makes an automated spraying device.

CALCULATIONS

1 .Selection of wire rope:
The depth of the groove should be selected such that the rope does not rub against the sheave or each other while entering, running or leaving the groove.
Angle of circular arc of the groove should not be less than 120 degrees.
The groove on the drum should be pitched so that there is clearance between neighboring turns of rope on that drum. Recommended clearance is up to 1.5mm for 28 mm diameter rope wire and 3mm clearance for diameter above 28mm.

2. Selection of battery:
Power = work done per second.
Power = Volt * current.
Backup Time of Sprayer = (Power stored in battery / Power consumed by motor)

3. Bolt Selection:

- Stresses in threaded bolts:
  1. Shear stress.
  2. Bending stress.

Shear stress (Γ): It is a force that causes layers or parts to slide upon each other in opposite directions.

Shear stress= Force/Area

Area=$A = \pi r^2$

Force=mass*g
Let Factor of Safety=4.

Bending Stress (σ): Bending stress is the normal stress that is induced at a point in a body subjected to loads that cause it to bend.
Bending stress=32*M / (π*d^3)
Where M= moment of inertia N mm.
M= (F*L)/2
∴By using Maximum principle stress theory,

$$\sigma = (\sigma/2)+\sqrt{(\sigma/2)^2+\Gamma^2}$$

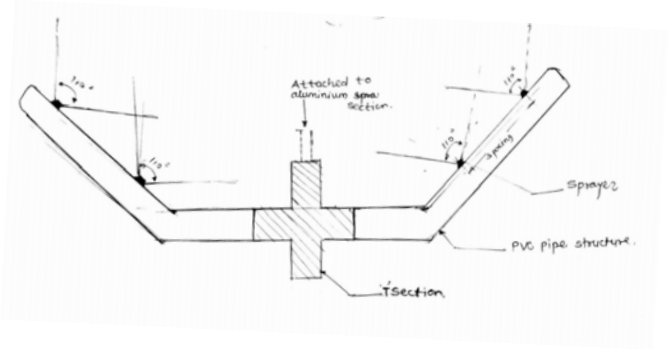
Condition for safe design:
∴Maximum stress<Allowable stress

4 .Design of pipe:
Pump Pressure = 3 bar.
Pump discharge = 3 ltr. /min .
Spray Pipe Material = Rubber.
Q = area*velocity.
V =Q/area..

5 .Selection of Motor:
Power = Volt*Current……. (1)
Torque= Load*radius of wheel
Let Factor of safety = 4
Also, Power = (2*π*N*T)/60…… (2)
From equation (1) and (2),
Therefore we selected motor with calculated rpm.

6 .Selection of Pump:
Two nozzles are joined to the arm therefore the pump required to produce the discharge is, =2*Q.
Therefore pump with above discharge and required pressure is selected.

Structural idea about model (Initial Stage):



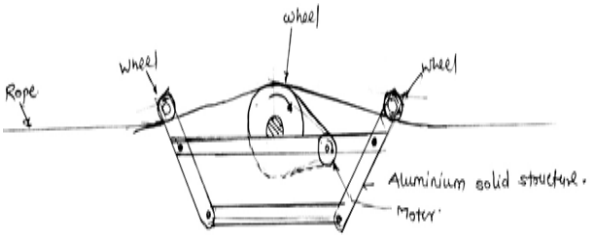


Fig. Initial stage device design

Actual device:

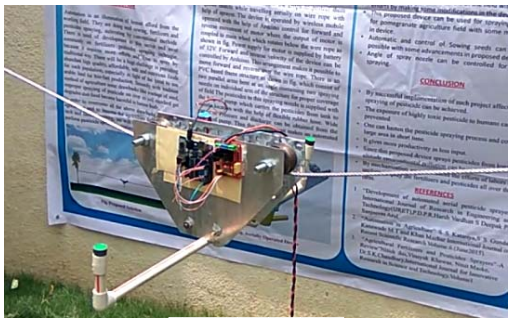


Fig.Actual model

Cad design (Final Design):

1. Complete cad assembly view of aerially operated spraying pesticides:

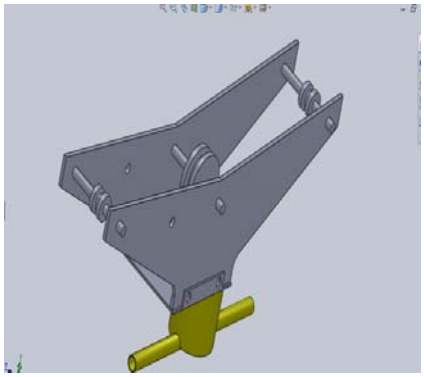


Fig.Cad design

Dimension:
Length= 315 mm.
Width= 4 mm.
Height= 140 mm.

2. Frame Structure:
Dimensions: Length: 315 mm.
Height: 140 mm.
Thickness: 4mm.
Material: Aluminum.

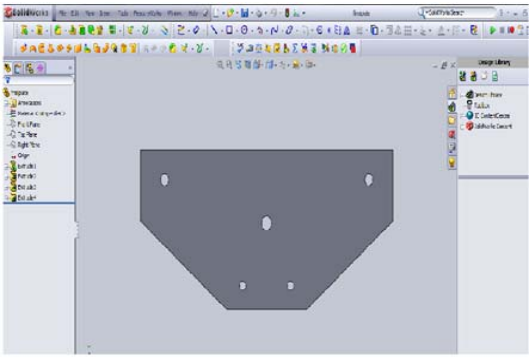


Fig. frame structure

3. Pulley Wheel:
Dimension: Outer Diameter: 50mm.
Inner Diameter: 10mm.
Groove angle: 4mm.

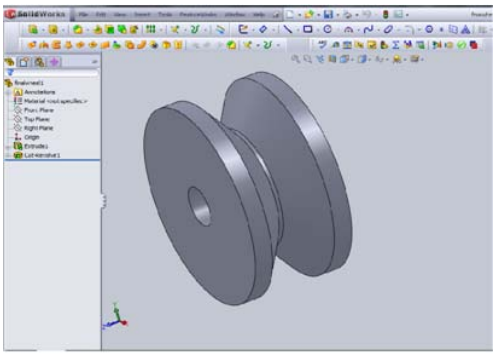


Fig. V grooved pulley with bearing fitted

5. Bolt design:
Dimension:
M10 bolt.
Material: Stainless steel.
Pitch =1.25mm.
Angle= 60 degree.

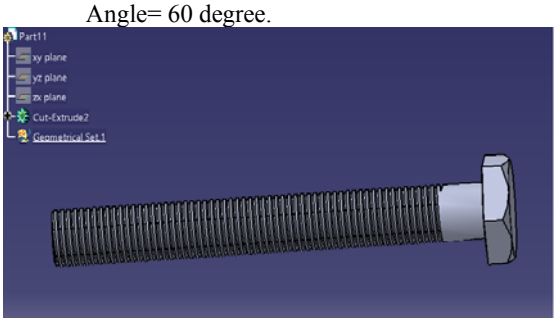


Fig. Bolt

Static Structural Analysis of Aerially Operated Spraying Pesticides:

1.Complete Assembly:

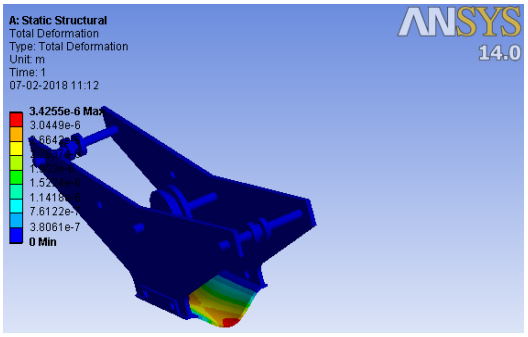


Fig. Analysis

2. Plate:

a. Static Structural:

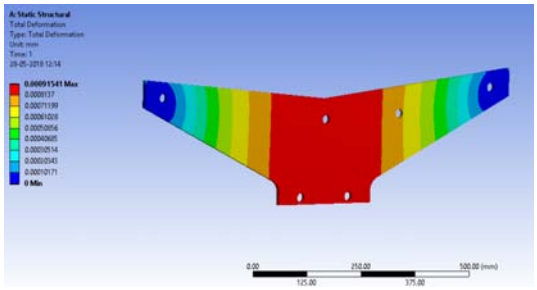


Fig. Static structural

b. Equivalent (von mises stress):

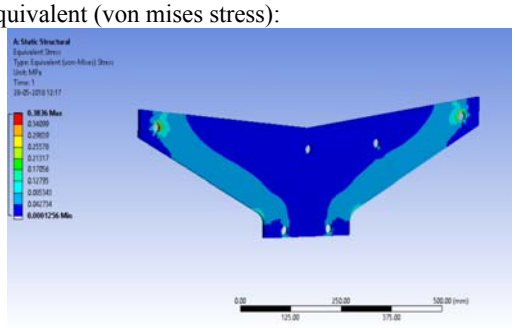


Fig. Equivalent (von mises stress)

3.Bolt:

a. Loading Boundary condition:

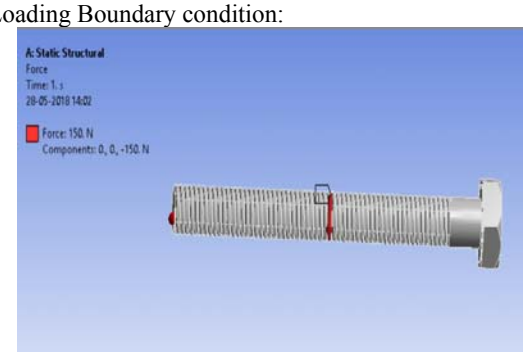


Fig.Bolt analysis

b. Total Deformation of bolt:

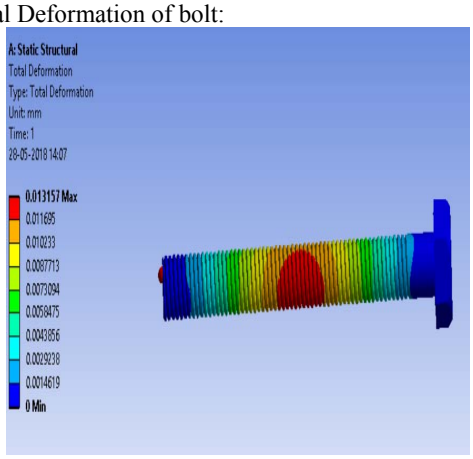


Fig.Total deformation

c. Equivalent (Vonn misses) Stress:

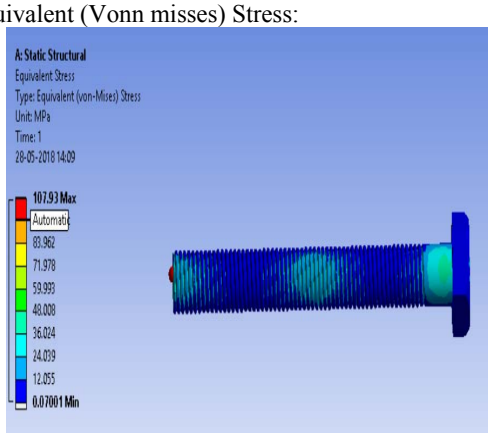


Fig.Stress analysis

EXPERIMENT AND RESULT

Description	Conventional method	Aerially operated pesticide sprayer
Pesticide	1 litre	0.75 litre
Labour charge	300 Rs per labour per day	300 Rs per labour per day
No.of labours	05	02
Labour charge	No.of labours×charge per day = 5*300=1500 Rs	No.of labours×charge per day = 02*300=600 Rs
Overall cost	Using blower with tractor =2,00,000 Rs	Using our proposed device =cost of htp pump+cost of device =14,233+9475 =23,708
Distance between two rows of plants	6.5 feet	5 feet

CONCLUSION

By application of such project spraying of pesticide can be done more efficiently as compared to conventional and by other ground operated vehicles. The contact of highly toxic pesticide to humans can be prevented. Amount of Labours required is less for spraying pesticides. It gives more productivity in less input. Since this proposed device of spraying pesticides also has less causes on environmental pollution. By making use of our method we can reduce the efforts of labors and also uniformly spray the fertilizers and pesticides all over the farm within less time as compared to other methods.

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