

Design and Analysis of Medium size agriculture sprayer and fertilizer dispenser

U.S. Kaur¹, A.U. Bhosale², P.A. Mali³

^{1,2,3}RMD Sinhgad School of Engineering Warje, Pune

Abstract - Agriculture operations are extremely labor intensive and often there shortage of labor and sometimes expensive for small farmers. The pesticide spraying and fertilizer dispensing are prominent of these operations that are done manually. The pesticide spraying is done using a back mounted spray pump whereas the fertilizer dispensing is done using hands. Mechanization of the above two operations if done will likely reduce considerable man hours and efforts and will be considerable economical. The paper discusses this possibility using a singular machine that combines both operations in ergonomic manner. The components of the system are displayed in the layout and the general arrangement of the combination is shown.

The paper elaborates the solution, its mechanical elements, and the design of the critical components of the sprayer mechanism. The critical components of the system are designed by theoretical method and the results are validated using Ansys workbench.

Index Terms - Agriculture sprayer, fertilizer dispenser, pesticide, economic, ergonomic.

I. INTRODUCTION

A sprayer is a unit used to spray a pesticide in liquid form. In agriculture, a sprayer uses spray nozzles to spray herbicides, pesticides, and fertilizers to agricultural crops. Sprayers are of different types depending upon how the pesticide tank is carried, namely.

- Backpack/knapsack
- Foot
- Garden
- Hand compression
- Power



The disadvantage of this system is that it is very heavy, has to be operated by hand and moreover carrying it on the shoulder is very tire some. hence need of an innovative type of sprayer.

II. LITERATURE REVIEW

A. Varikuti Vasantha Rao *B. et al (1)*

In this paper, the authors discuss the design and fabrication of an innovative multiple power supplied fertilizer sprayer A two stroke petrol engine which conventionally used to power the sprayer is replaced DC which is run using a battery unit that can be externally charged. The application of the unit is done for spraying fungicides, pesticides, etc.

B. Laukik P. Raut et al (2)

The authors in their paper bring forth the ability of mechanization towards the conservation of agriculture inputs, losses prevention thereby reducing the labor cost per unit and thus attain the best productivity. The authors also show the disadvantages of the conventional agriculture practices in spraying and weeding and propose a combination machine for the spraying and weeding activity.

C. Sumit d. Raut et al (3)

The authors in their study describe a pedal operated reciprocating pump for application in drainage lines, orchards and large irrigation projects. In order to evaluate performance of the pumps for various suction heads different pump models were tested. The said pump was proposed to replace the conventional backpack sprayer which is in traditional use with the objective to reduce the human effort.

The proposed pump was said to need less power input there by operated continuously over a span of more than 2 hours by an adult labor in agriculture field continuously without getting tired.

The authors also stress the importance of pump in generating local employment as it can be made from locally available materials, using simple skills of manufacturing at low cost. The pump shows utility in

irrigation of vegetables, seed beds etc. for low to medium plot size.

D. Shivaraja kumar et al (4)

Application of pesticide is for killing insects or control their rate of reproduction. Through optimum performance with minimum efforts the sprayers are used to apply these pesticides, and herbicides, fertilizers are applied to crops in agriculture in order to obtain the maximum output as agricultural produce. Authors show some difficulties in development of sprayers such as increase in tank capacity results in cost augmentation, labour cost as well as spraying time. Authors propose various solutions targeted to reduce the above-mentioned problems and also target to reduce the fuel cost in pump operations, The proposed wheel operated pesticide spraying equipment consumes less effort and time and avoids the person who sprays pesticides with any contact of pesticide ejecting front of the nozzles. The mechanism incorporated in this sprayer is reciprocating pump, which is driven by the wheel system.

III.LITERATURE GAP

The literature careful study shows various types of sprayers and devices are available for spraying of pesticide. Similarly, the fertilizer dispensing is done manually or through the attachment to tractors It is also observed that the operations are done individually although the combination device is not studied or fabricated. Combination of both operations in one vehicle will reduce the cost of operation and will be beneficial to the farmer.

IV PROBLEM STATEMENT

Manually operated sprayers are slow and labor intensive so lots of time and cost is utilized in sprayer more over the pesticide chemicals are injurious and hazardous to health 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 you breathe / eat / drink pesticide.

V PROPOSED SOLUTION

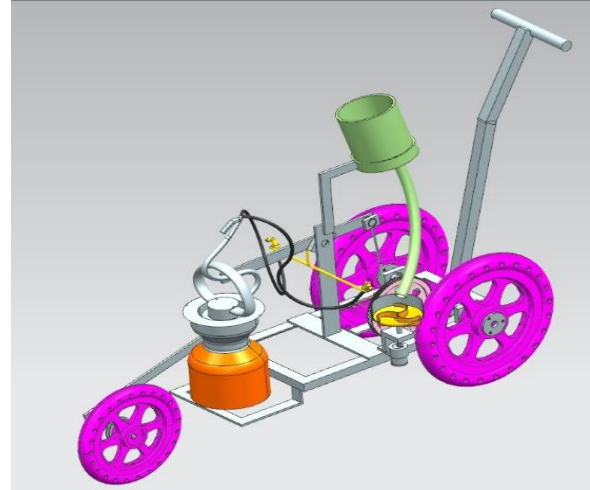


Figure 1 : Pesticide sprayer with fertilizer dispenser
The innovative agricultural sprayer with fertilizer dispenses comprises of the following subsystems.

a) Chasis or Base frame

Fabricated from mild steel the base frame holds the entire unit assembly of the sprayer and dispenser. The rear side carries the drive wheel shaft that carries the drive wheels which provide motion and motive force to the machine.

b) Crank drive assembly

The crank drive assembly comprises of the driver gear pair as pinion on rear shaft, and the spur gear on crank shaft. Thus, when the vehicle is pushed in forward direction the motion of wheels rotates the shaft and thereby the drive train, crank, and the pump reciprocating arm,

c) Reciprocating sprayer Pump System:

The reciprocating pump with integrated air tank of three-liter capacity fabricated from light weight plastic molding that helps make the vehicle light weight.

d) Fertilizer storage and control:

The fabricated container is used for the storage of the fertilizer (urea /dap etc) and a U-PVC ball valve is used to control the flow.

f) Fertilizer dispenser:

The fertilizer dispenser mechanism comprises of a disk with curved r vanes that will throw the fertilizer dropped on to it through centrifugal force created using a high-speed dc motor coupled to the dispenser disk shaft held in ball bearings.

g) Pesticide sprayer mechanism

Nozzles are for the pesticide sprayer on either side of the pump thereby covering either side of the bed.

VI DESIGN AND ANALYSIS OF COMPONENTS

a) Analysis of wheel shaft:

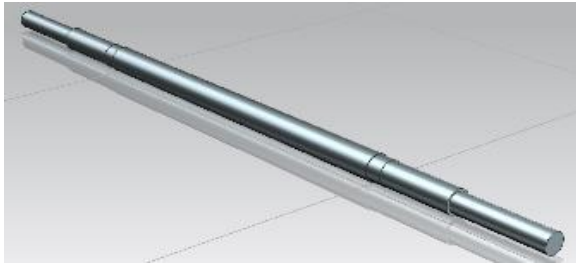


Figure 2 Wheel shaft

Material: EN24

Maximum torque = 1.12 N-m

a) Considering pure torsional load;

$$T_d = \Pi * f_s * d^3 / 16$$

Maximum torsional stress (th) $f_s = 3.3 \text{ Mpa}$

Analysis of wheel shaft

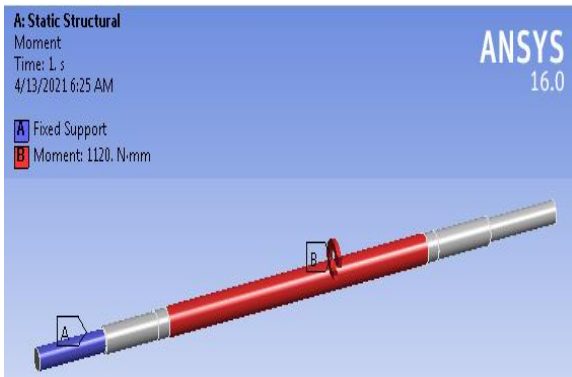
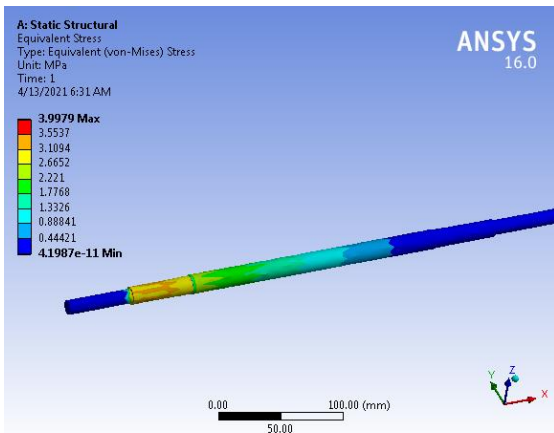


Figure 3 Boundary conditions and loading of wheel shaft

Maximum stress in wheel shaft



The maximum stress induced in the rear wheel shaft is 3.9 Mpa by analytical method

b) Analysis of crank:

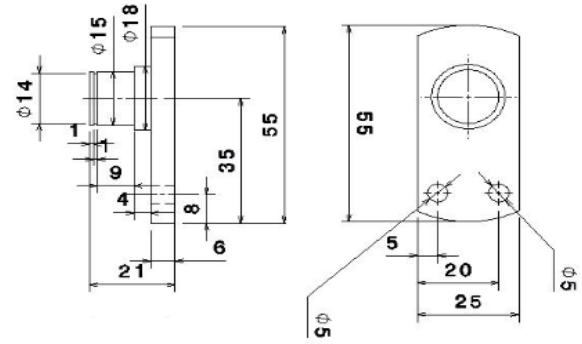


Figure 4 Crank

Material: EN9

Maximum force = 32 N-

a) Considering shear load;

$$f_s = F / (\pi \times 14^2 / 4)$$

Maximum shear stress (th) $f_s = 0.27 \text{ Mpa}$

Analysis of crank

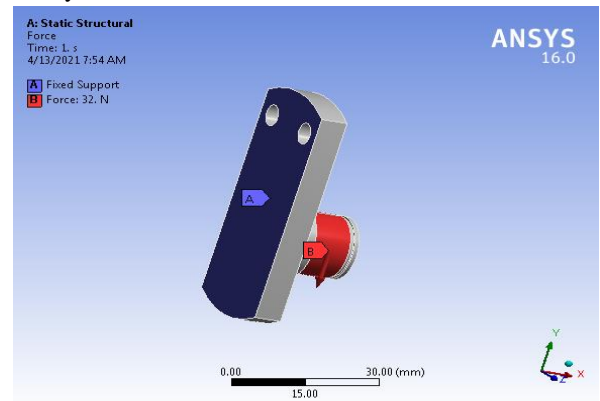
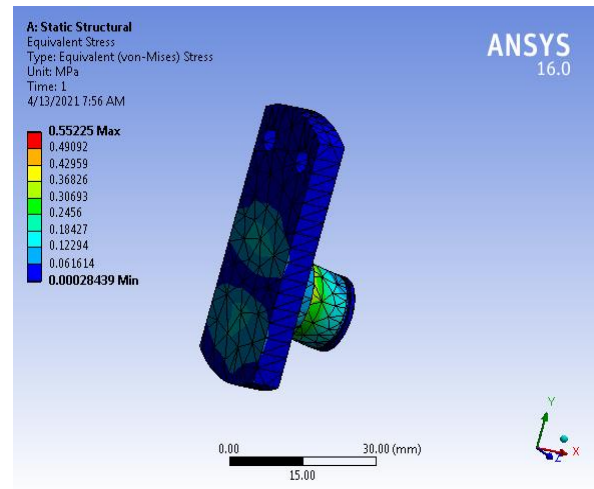


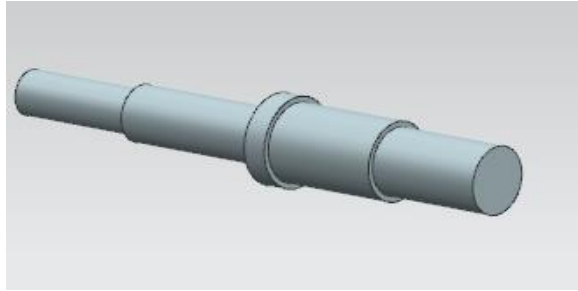
Figure 5 Boundary conditions and loading of crank

Maximum stress in crank



The maximum stress induced in the crank is 0.55 Mpa by analytical method

c) Analysis of dispenser shaft



Material : EN24

Maximum torque = 0.2 N-m

a) Considering pure torsional load;

$$T_d = \pi * f_s * d^3 / 16$$

Maximum torsional stress (th) $f_s = 1.98 \text{ Mpa}$

Analysis of dispenser shaft

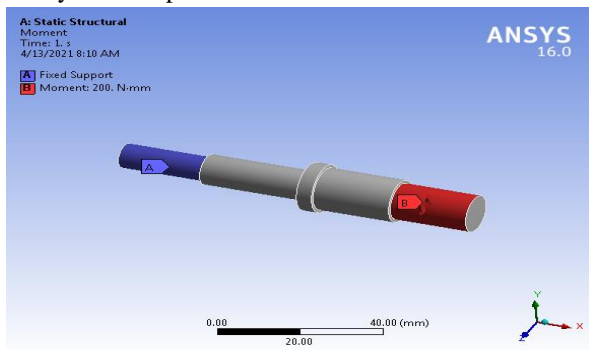
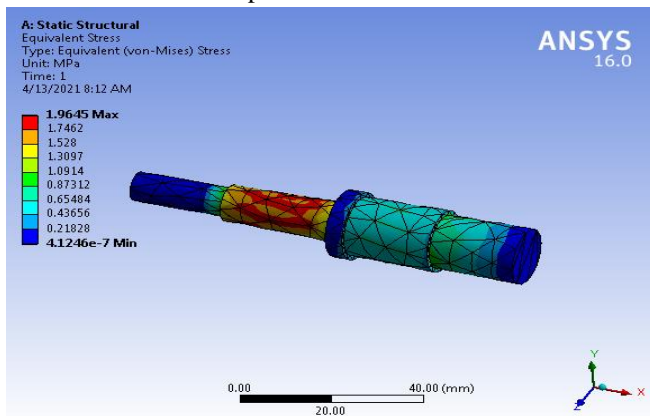


Figure 6 Boundary conditions and loading of dispenser shaft

Maximum stress in dispenser shaft



The maximum stress induced in the dispenser shaft is 1.96 Mpa by analytical method

VII CONCLUSION

Various types of sprayers and devices are available for spraying of pesticide. Similarly, the fertilizer dispensing is done manually or through the attachment to tractors. It is also observed that the operations are done individually although the combination device is not studied or fabricated. Combination of both operations in one vehicle will reduce the cost of operation and will be beneficial to the farmer. The critical components of the system namely the wheel shaft, crank, dispenser shaft was checked by theoretical as well as analytical method and the parts were found to be safe.

VIII FUTURE SCOPE

The manufacturing of the combination system will be done by suitable methods. The assembly of the components will be done, and the testing will be done to determine the performance of the sprayer and fertilizer dispenser mechanism.

REFERENCES

- [1] Multiple Power Supplied Fertilizer Sprayer Varikuti Vasantha Rao*, Sharanakumar Mathapati*, Dr. Basavaraj Amarapur International Journal of Scientific and Research Publications, Volume 3, Issue 8, August 2013 1 ISSN 2250-3153
- [2] Laukik P. Raut, Smit B. Jaiswal, Nitin Y. Mohite, "Design, development and fabrication of agricultural pesticides sprayer with weeder", International Journal of Applied Research and Studies (IJARS) ISSN: 2278-9480 Volume 2, Issue 11, pp 1-8, Nov. 2013
- [3] Fabrication of pedal operated reciprocating pesticide sprayer for agricultural and drainage line. Prof Sumit d Raut, Prof Kamlesh R Banarse, Roshan R More. IJPRET. Volume 2, December 2014
- [4] Development of wheel driven sprayer, Shivraja Kumar, Parmeshwara Murthy International journal of Engineering Research-Online Vol.2., Issue.3., 2014.
- [5] PSG design Data Handbook, 2014
- [6] Design of Machine Elements, V B Bhandari, McGraw Hill India, 2018