Design and Analysis of an Automatic Seed Sowing Machine Using SolidWorks and ANSYS Tools

Gaurav Kumar, Rishabh Singh, Pavan Kumar, Twinkle Rajput, Eram Neha, and Yogesh Shrivastava

Abstract To meet future food demands, it is essential to provide new technologies to the farmers. There are several processes, viz. excavation, planting, irrigation, etc. for which the farmers are still worried. Mechanization reduces the cost of labor and improves overall productivity without any effect on the quality of the soil. Hence, it is necessary to provide them with some useful economic solutions for these problems. In the present work, the problem of seed sowing has been addressed. The conventional method of seed sowing is not efficient and is time-consuming. In the present work, a multifunctional seed sowing machine has been designed, which can sow the seed and can discharge the fertilizer simultaneously. The design of the machine has been done using SolidWorks, and the analysis has been done with the help ANSYS workbench 15.0. From the result, it has been found that the seed sowing machine is safe under self-weight and in other loads.

Keywords Sowing machine · Von mises stress · SolidWorks · ANSYS workbench

1 Introduction

Agriculture makes a massive contribution to the Indian economy for a very long time [1]. In the current situation, a massive area of our cities is being used for construction and other works which are hampering the development of agriculture necessary. Moreover, with the limited land, small farmers face economic crises and have very limited resources to enhance their farming. Sowing of seed is the foremost essential step in farming. However, manual seed sowing usually causes the wastage of seeds and lower productivity [2, 3]. The manual technique incorporates sowing the seeds by throwing them by hand. The main criteria that need to be focused while sowing the seed are; the seeds should be at the proper spacing. The seeds should not get a break during sowing. The amount of seed to be sown in an area should be uniform. However, all these cannot be fulfilled using manual sawing [4]. Considering the

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present scenario, various sowing machines are available. However, they have several limitations such as:

1. The weight of the machine is more.
2. No arrangement for seedbed preparation.
3. Improper compaction of soil over furrows.
4. The adjustment of row spacing is improper.
5. The cost of the machine is more.

Hence, to overcome all these limitations, it is required to design a new machine. A lot of researchers have contributed to this field for the development of the sowing machine [5–7]. Researchers have developed a multi-seed sowing machine that has proved that the mechanical system is wonderful over the prevailing machines as it can manipulate the seed and fertilizer depth and proper utilization of seeds and fertilizers may be completed with much less loss [8]. It is relative to low cost and quite simple for the layman to function [9]. The layout and fabrication of automated seed sowing machine for the agricultural subject showcased that the yield loss may be substantially reduced with the aid of utilizing operated by hand seed and fertilizer planter. This seed and fertilizer planter can fulfill most of the farmer and subject requirements effectively at some point in the peak season [10]. However, these machined either need electricity or fuel which sometimes limits its uses.

Some of the researchers have developed the layout of a solar-powered seed sowing machine that operates on solar power. While in comparison with specific traditional seed sowing techniques, it has less guided energy intake. Pollutants are managed in conjunction with a regulation on the sowing rate and seed spacing [11]. In this design, the entire weight of the solar panel, battery, and the hardware has been placed on agribot which is supported by the chassis. This makes it suitable to perform operations skillfully and efficiently. Wireless connectivity among the system and the controller has also been designed by the researchers [12, 13]. However, all these designs have certain flaws, as they do not need the basic requirement and facilities available to the farmers in a country like India. Hence, in the present work, efforts have been made to design a sowing machine that may meet the basic requirement of the farmers. The proposed benefits of the developed machine are as follows:

1. In this model, seed sowing method is automatic to reduce the human effort and increase the yield. The plantation of seeds has been accomplished efficaciously using DC motor.
2. The space among the two seeds is managed by the use of a microcontroller.
3. Different kinds of strategies of seed sowing and fertilizer placement inside the soil can be performed.

The steps followed in the present work starts from the 3D modeling of the sowing machine followed by the finite element analysis (FEA). After which the design has been analyzed using ANSYS software.

2 Methodology

The study begins with the requirements of agricultural seed planter. The study includes an overview of the current manual as well as an automatic seed planting process and formulation of the initial design proposal for the proposed new method of seed planting. The methodology steps are shown in Fig. 1. The steps involved are as follows:

STEP 1: Collect all required authentic data for studies such as materials properties, dimensions of structures, and boundary conditions.
STEP 2: Find previous research and studies done by other researchers. Collect information by this study for innovation.
STEP 3: Create a 3D model using SolidWorks 2016. SolidWorks is a 3D modeling software developed by Dassault System. Dassault System is USA-based company. This software developed in 1993. It creates part files, assembly files, and drawing files. Part files have.sldprt extension file name. Assembly file has.sldasm extension name. The drawing file has a.slddwg extension name. Create an IGES file to import in ANSYS workbench.
STEP 4: Import IGES file ANSYS workbench. IGES means initial graphics exchange specification. This file also is known as the un-parametric file. Created a finite element model (FEA).
STEP 5: Apply mass of 10–10 kg seeds on Hopper and seedbox. Also apply motor torque on machine under ANSYS workbench. Apply fix support on all three wheels at the bottom face.

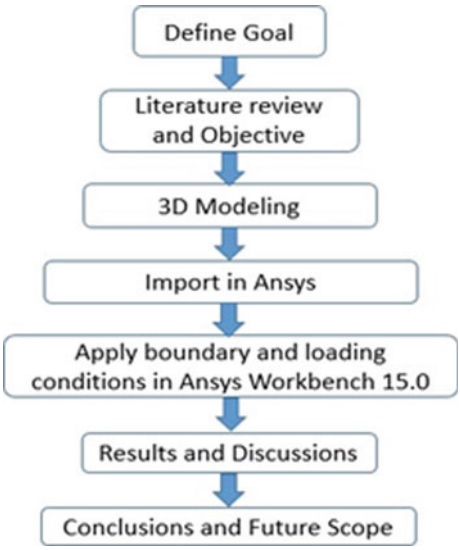


Fig. 1 Flow chart

STEP 6: After applying load and boundary conditions on the machine, apply solution process and then obtain results such as total deformation and von Mises stress.
STEP 7: Study the results and behavior of the machine after applying load and create conclusion and future scope.

3 3D Modeling and FEA

A 3D model of the seed sowing machine has been developed in SolidWorks 2016. The model has been first analyzed using FEA as shown in Fig. 2. This machine has mainly 10 components which play a very important role in the working seed sowing machine. That are rear wheel, the front wheel, frame, seed sowing Disk, seed hopper, chain drives, battery, microcontroller unit, seedbox, and funnel. The proposed model is analyzed to obtain net mass, net volume, and equivalent stress acting on the machine. The obtained mass is 66.02 kg as shown in Fig. 3a, and the obtained volume is 9497084.74 mmˆ3 as shown in Fig. 3b.

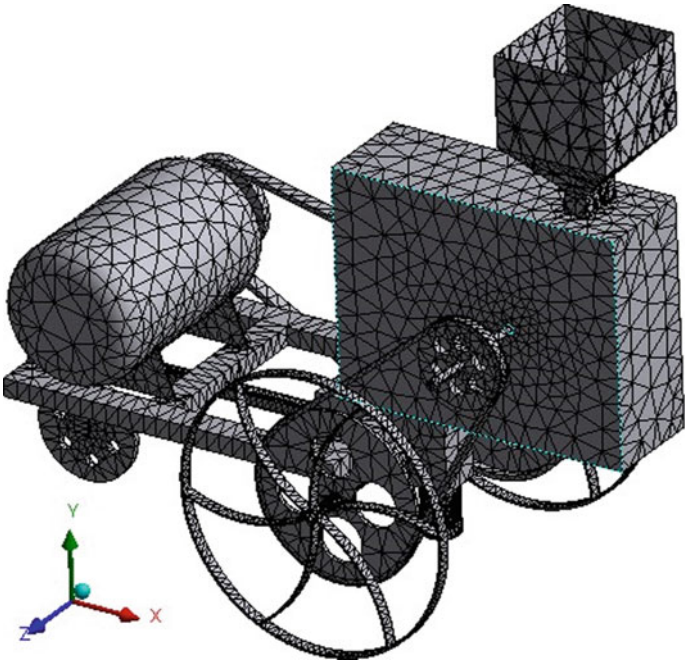


Fig. 2 Finite element model (FEA model) of seed sowing machine

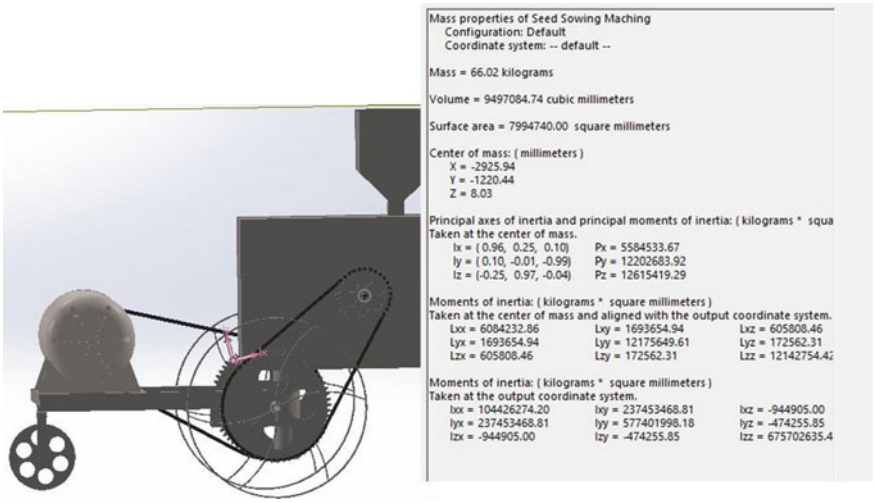


Fig. 3 **a** Seed sowing machine center of mass **b** 3D model calculation data

3.1 Un-parametric CAD Format

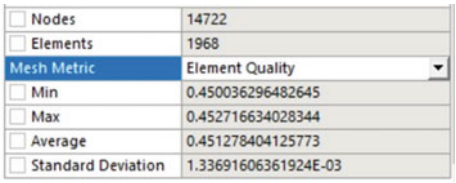
To share the 3D model to any other software, un-parametric files are used. Un-parametric format merges all features in a single object, and due to this, it cannot be changed into the previous sketch and feature. This format can be open accessed in 3D model software. But if anyone wishes to relocate the previous steps, it would be let you do that. Some un-parametric formats are IGES, STEP, etc.

3.2 Parametric CAD Format

In such a format, the previous steps of CAD model can be relocated, and changes can be done easily. Some areas extensions for Inventor are.IPT and.IAM and for SolidWorks,.sldprt,.sldasm, etc.

Number of Elements and Nodes
For the meshing of setup, ANSYS created 1968 and 14,722 no. of elements and nodes, respectively, as shown in Fig. 4. For mashing, minimum size used is 0.4500 mm, and the maximum size used is 0.4527 mm.

1D Elements
ANSYS software uses the FEA method for analysis and generates results according to the requirements. For simple geometry, 1D element is being used that can be of the linear, quadratic, or cubic type.



Nodes	14722
Elements	1968
Mesh Metric	Element Quality
Min	0.450036296482645
Max	0.452716634028344
Average	0.451278404125773
Standard Deviation	1.33691606361924E-03

Fig. 4 No. of elements and nodes

2D Elements

ANSYS software uses the FEA method for analysis and generates results according to the requirements. For area, geometry 2D element is being used that can be of the linear, quadratic, or cubic type.

3D Elements

ANSYS software uses the FEA method for analysis and generates results according to requirements after applied required inputs. For area, geometry 3D element is being used that can be of the linear, quadratic, or cubic type.

4 Results and Discussions

The 3D model created in SolidWorks 2016 is then imported in ANSYS workbench 15.0. After importing the file and applying all required materials properties of machine components, boundary conditions have been applied as fixed support on all three wheels.

For applying the load, it has been considered that 10 kg of seed is in the Hopper and the seedbox. Then torque has been applied to the motor to visualize the analysis using ANSYS workbench 15.0. The obtained total deformation and von Mises stress are shown in Figs. 5 and 6. The seed sowing machine has total deformation (max value) of 0.6396 mm, and max von Mises stress is of 23.137 MPa. From the results, it has been obtained that stress is 23.137 MPa which is very less as compared to the yield strength of mild steel that is 270 MPa. Moreover, the total deformation is 0.693 mm that is very less, as the weight of the machine is nearly about 66 kg. Hence, it may act as a portable machine that can be used easily. Machines have less stress and less deformation that means it is safer and more economic.

5 Conclusions

In the present work, the design and analysis of the seed sowing machine have been done. The design has been analyzed using FEA. From the analysis, it has been found that the design is acceptable because the obtained value of stress is 23.137 MPa which is very less as compared to the yield strength of mild steel that is 270 MPa.

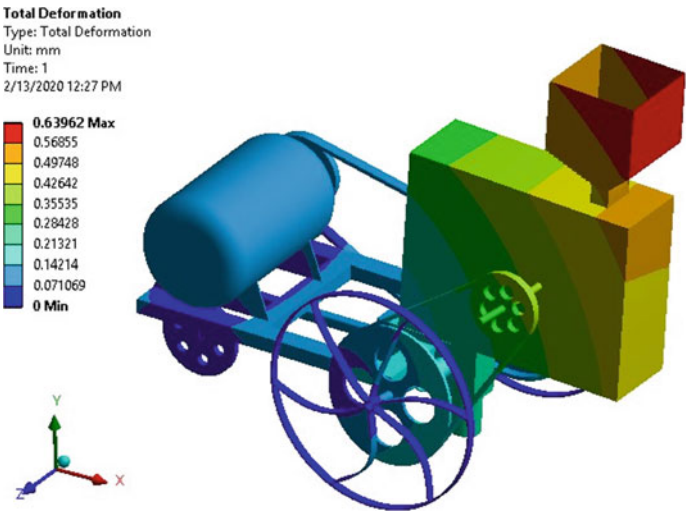


Fig. 5 Total deformation of seed sowing machine

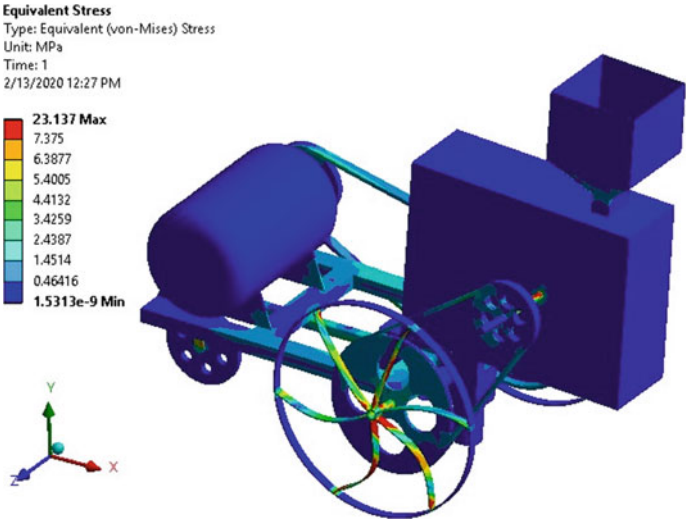


Fig. 6 Von Mises stress of seed sowing machine

Also, the total deformation is 0.693 mm that is very less. The calculated weight of the machine is found to be 66 kg. Moreover, the machine has less stress and less deformation that means it is safer and more economic. In the near future, research may be conducted to add automatic fertilizing setup and automatic digging system to this machine.

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