Modeling and Finite Element Analysis of Post Hole Digger

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Abstract— This paper presents the modeling and stress analysis of a manually operated digger for plantation of horticulture crop. Helical blade arrangements are presented with the potential for removing soil from earth to reduce plantation time. 3-D model of digger is conceptualized and stress analyses done using FEA simulation for safe design.
Key words: Product Design, Conceptual Design, Stress Analysis, Form Equipment Design, Post Hole Digger

I. Introduction

Agriculture is the backbone of Indian economy. About 60-70% population of India depends upon agriculture and allied activities. So for developing and maintaining country's economy, it is always necessary to develop and advance the form equipments.

For accomplishing the digging operation of plantation of horticulture crop like banana tree, there are traditional hand tools like pick axe and spade etc. By using such hand tools, time required for completing the operation increases. Also this type of implements can cause serious injuries to human labour. Also these methods largely depends upon availability of labour and that too in proper time of planting as the delay in planting operation may reduce the yield of the banana.

The need was felt to design and develop post hole digger for digging the pits for plantation of horticultural crops. It was also kept in mind that the design will be simpler, affordable by small and marginal farmers of the region. It will be easily carried form one place to other; it will not have any moving parts. The machine will incorporate the screwing action for operation of digger which certainly will penetrate in soil easily also will reduce time required and the amount of drudgery involved.

A. Design Background

The fundamental purpose of any post hole digger is to dig a deep, narrow. Most often, this is done in order to set a deck post, erect a fence, or fix some sort of structural column in the ground. While the speed and ease with which a gas powered auger can dig post holes may be appealing to some, the simplicity, cost efficiency and relative safety of a mechanical post hole digger is more than sufficient for most users and applications. Post hole diggers have come in many shapes, sizes, and have included numerous functionalities to improve the physical experience of using such a tool, but the room for improvement is still exists. Some of the areas of improvement, along with their corresponding design goals and a few potential remedies that have been identified throughout the design process for a mechanical post hole digger include ;

– Weight -- Optimize weight to reduce physical demand and still maintain robustness
– Ground Penetration -- Increase the ability to penetrate the soil
– Dirt Removal -- Increase removal capacity and still maintain ease of use
– User Convenience -- Make the process as comfortable and easy as possible.

B. Modeling

Modeling includes the three main components.

1) Main Shaft:

The shaft is a rotating machine element which is used to transmit power from one place to another. The shaft of the developed manually operated digger acts as frame as it joins the handle and the digging unit together. Also this shaft converts the twisting motion and power applied manually to the handle lever in to the screwing action or motion of the digging unit. For accomplishing this circular solid rod is used as a main shaft for this digger. The material used for this shaft is mild steel.

2) Lever:

The lever is used to lift a load by the application of a small effort. Sometimes it is used to facilitate the application of force in the desired direction. In this case simple circular solid shaft is incorporated to act as lever. It is accomplished by joining this shaft of lever perpendicular to main shaft and is always parallel to the ground. The diameter of the lever of the developed digger was fixed as 20 mm considering the griping diameter of average person.

3) Digging Unit:

The main function of digging unit is to make hole in the ground for plantation of horticultural crops. In this equipment the digging operation is accomplished by twisting action of lever which causes the circular motion to the digging unit through the main shaft. The digging unit comprises of helical screw flights joined at the end of main shaft. The helical screw flights are joined peripherally on the shaft. The construction is such that the peripheral diameter of the screw is increased from bottom of the screw.

This digging unit is comprised of two sections namely primary digging section and secondary digging section. The primary digging section is incorporated for small initial scouring of soil; the construction of this unit is such that the small diameter screw helix with increasing diameter is incorporated to accomplish the operation.

The working secondary unit is same as that of primary unit. The only difference in these two units is diameter of the helix. The major digging operation undertakes by this unit. Both of these units are constructed in mild steel. The maximum diameter of rod used for primary digging unit was 32 mm. The construction of the whole digging is such that the secondary digging unit is joined between primary digging unit and the main shaft. Optimum design parameters from design consideration are

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Sr. No.	Particulars	Specifications
1.	Length	100 cm
2.	Width	50 cm
3.	Diameter	30 cm

Table 1: Overall Dimensions of Developed Manually Operated Digger

Sr. No.	Particulars	Details
1.	Material	MS Rod
2.	Diameter	20 mm
3.	Length	50 mm

Table 2: Details of Lever

Sr. No.	Particulars	Details
1.	Material	MS Rod
2.	Diameter	20 mm
3.	Length	930 mm

Table 3: Details of Main shaft

Sr. No.	Particulars	Details
1.	Material	MS Rod
2.	Maximum Diameter	32 mm
3.	No. of Helix	10
4.	Maximum Pitch	6 mm
5.	Length	50 mm

Table 4: Details of Primary Digging Unit

Sr. No.	Particulars	Details
1.	Materials	MS Sheet
2.	Maximum Diameter	300 mm
3.	No. of Helix	8
4.	Maximum Pitch	50 mm
5.	Length	250 mm

Table 5: Details of Secondary Digging Unit

C. 3D model

Modeling of digger is done in solid works as per design specification. For rubber grip is given to give proper grip and avoid slip during penetration on earth whole digging hole.

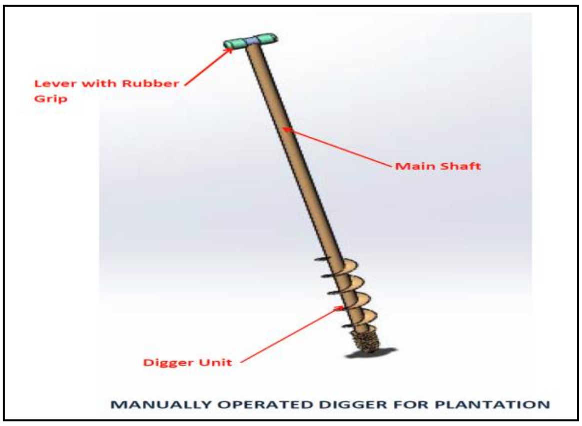

Fig. 1

II. Stress Analysis and Result

The digger modeled subjected to static and dynamic loading. These loading conditioned are analyzed using FEA simulations in solid works.

A. Static analysis

Static analysis of digger has been done for compression and torque load for stress, displacement and strain. It includes Von mises stress from 0.073 N/mm^2 (MPa) to 176.582 N/mm^2 (MPa) and in safe operating range.

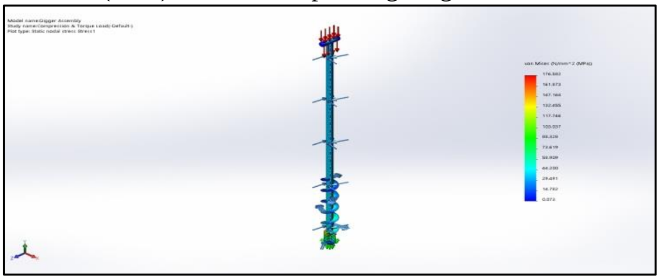

Fig. 2: Von mises stress

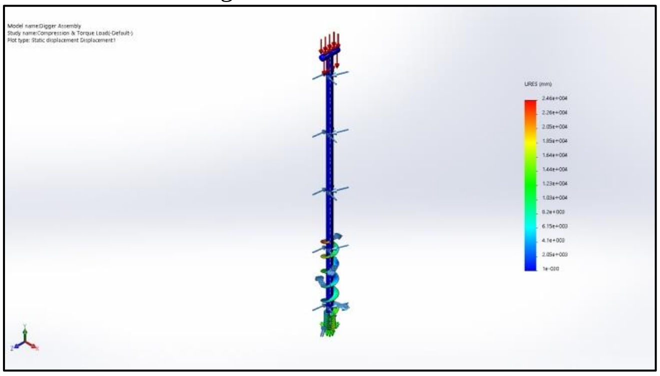

Fig. 3: Displacement

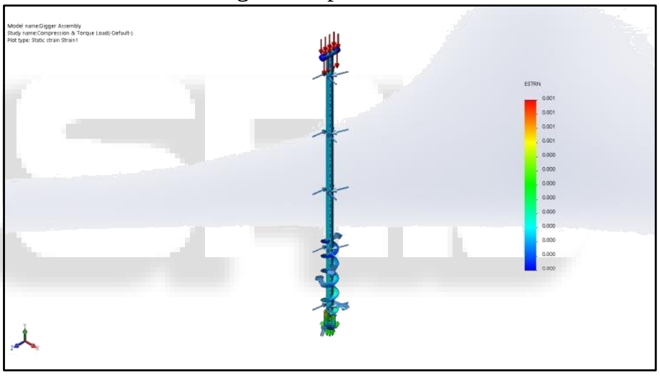

Fig. 4: Strain

For above we can conclude that digger is safe for the compression & Torque load, hence design is safe for the requirement.

After result maximum stress developed is low range at (2.86e + 002) were design is of the digger are at higher of (3.393e+003) were total strength of the mild steel is 270 N/mm.

1) Tensile load:

Tensile Load applied at upward direction of the handle to check the maximum pull of the model and result observed as threading of : 1e+016 and shaft having pull of : 1.84 mm.

The value observed as very low to damage the shaft and threading if the digger and so the result show the safe design.

2) Fatigue load:

Result show the digger having cycle test of 1000 cycle loading with operation of 12 RPM to remove the mud from the land and the cutter found deformation of 0.1 mm as minimum and in extreme case maximum of 1.2 mm. S N curves for Cast Carbon Steel and Cast Alloy Steel is similar. Hence both have same fatigue limit.

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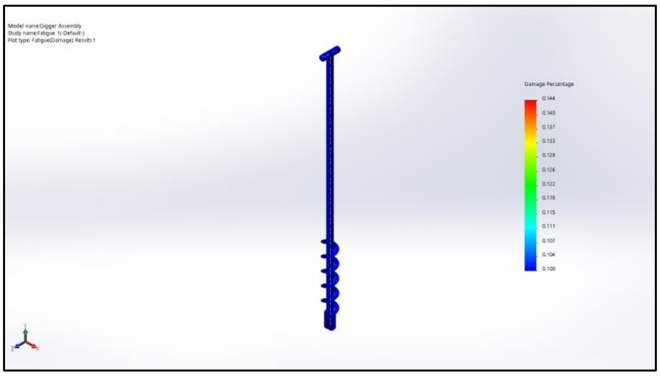
Fig. 5: Damage Plot

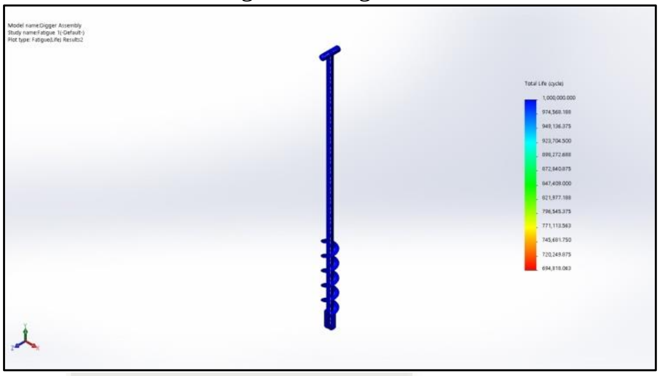
Fig. 6: Life Plot

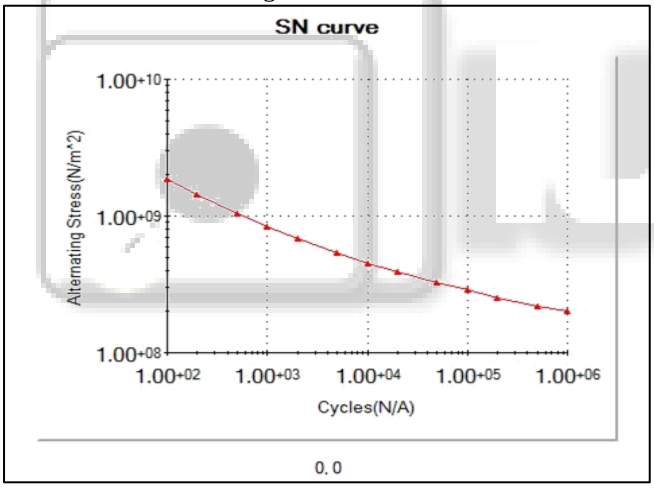

Fig. 7: SN CURVE for Cast Carbon Steel

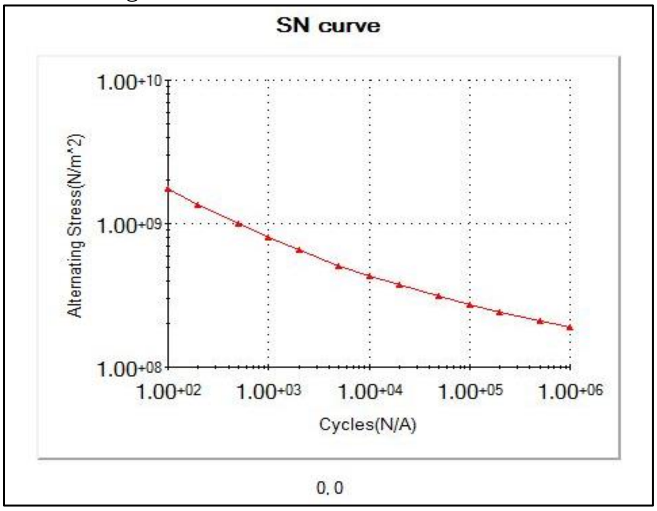

Fig. 8: SN curve for Cast Alloy Steel

III. CONCLUSION

A conceptual design for post hole digger is presented. The post tool holders are analyze for static load, tensile load and fatigue load analysis. The FEA results from a virtual simulation stress analysis for compression and torque loading demonstrate that the proposed design is safe. Further work involves manufacturing it and detailed performance testing, design optimization and user acceptability testing in order to produce a working product for use in agriculture industry. It is hoped that the solution offered in this paper would contribute to the ease of plantation of horticulture.

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