International Journal of Synergy in Engineering and Technology
IJSET

Design and analysis of mini transplanting shovel for seedlings

Siti Najwa binti Halias[1], Raja Manisa binti Raja Mamat[1*], Mohd Hairy bin Basir[1]

[1] University College TATI, Teluk Kalong 24000 Kemaman, Terengganu, MALAYSIA.
*Corresponding author: raja_manisa@uctati.edu.my

KEYWORDS

Transplanting
Shovel
Autodesk
FEAs
Steel material

ABSTRACT

In agriculture and gardening, transplanting or replanting is the technique of moving a plant from one location to another. Shovel as a tool resembling a spade with a broad blade, typically used for transplanting and replanting process. This research is about design and analysis of mini transplanting shovel with aims of minimize the impact of transplant shock and, to keep the root system intact and soils are not shaken out when moving a plant. The design of mini transplanting's shovel is carried out using Autodesk Inventor Professional 2019. It is then analyzed through Finite Element Analysis (FEA) by using Autodesk Inventor Professional 2019 to investigate the performance of propose design in term of material suitability, von misses stress, strength, safety factor and displacement. Based on analysis, steel material gives the best performance of stress 307 MPa with 15 safety factor and 3.01 mm displacement compared to mild steel and alloy steel. In conclusion, design of mini transplanting's shovel may provide benefits to the user.

1.0 INTRODUCTION

In agriculture and gardening, transplanting or replanting is the technique of moving a plant from one location to another. Most often this takes the form of starting a plant from seed in optimal conditions, such as in a greenhouse or protected nursery bed, then replanting it in another, usually outdoor, growing location. Transplants are used infrequently and carefully because they carry with them a significant risk of killing the plant (Simson S., 2010). Four tools needed for transplanting trees are spade/shovel, empty containers, yard cart and water jugs (Jeeler Johnson, 2017).

Sometimes plant die as a result of the move and it called as transplant shock. Plant transplant shock is caused by harm to the plant roots during transplanting process. Many new gardeners do not consider minimizing transplanting shock since they have never experienced the loss of plant dying during transplanting. When dig or move plants, the root system is bothered a bit and shaken the soils. Hence, this mini transplant shovel is designed to minimize the impact of transplant shock and, keep the root system intact and soils are not shaken out when moving a plant (Heather Rhoades, 2020).

Received 30 November 2021; revised form 17 December 2021; accepted 24 December 2021

Two main objectives to achieve the goal are to design a mini transplanting shovel using 3D CAD software and to analyse transplanting shovel's design through Finite Element Analysis (FEA).

This project is concern on transplanting of small plant. Hence, design of shovel only suitable for seedlings or light weight small plant. Besides, the functions of this shovel are limited for digging, lifting and moving seedling without damaging it. Autodesk Inventor as 3D CAD software will be used for designing and analysis stages. Size of the shovel is supposed to be 22 cm (L) x 10 cm (W).

2.0 EXPERIMENTAL PROCEDURE

The engineering design process is a methodical series of steps that engineers use in creating functional products and processes. The process is highly iterative which is parts of the process often need to be repeated many times before another can be entered though the parts that get iterated and the number of such cycles in any given project may vary.

It is a decision making process (often iterative) in which the basic sciences, mathematics, and engineering sciences are applied to convert resources optimally to meet a stated objective. Among the fundamental elements of the design process are the establishment of objectives and criteria, synthesis, analysis, construction, testing and evaluation.

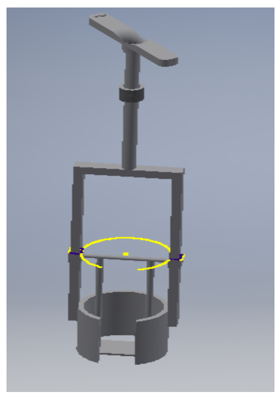

Figure 1: Design Concept 1

Design concept 1 (see in Figure 1) is designed with a long handle. The structure of the frame by carbon steel to increase the strength of the shovel head when pulled by humans. adjusters are also added to obtain sufficient quantities of soil and support the soil so that it does not loosen and break.

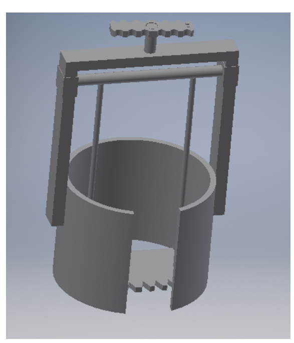

Figure 2: Design Concept 2

Design concept 2 (see in Figure 2) is designed with short handles. The structure of the frame by carbon steel is similar to the design concept 1. The design of the blade in the frame which has a tooth is added to facilitate the process of raking the soil well.

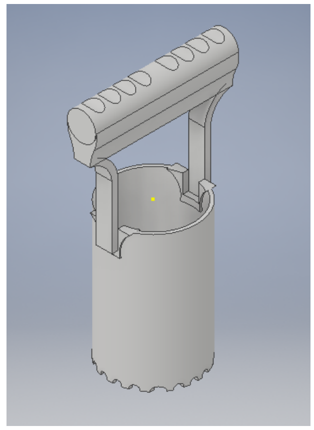

Figure 3: Design Concept 3

Design concept 3 (see in Figure 3) is designed with a comfortable grip. The simple frame structure is designed according to the standard sapling measurements and added to the jagged design below to grip the ground more strongly supporting the saplings.

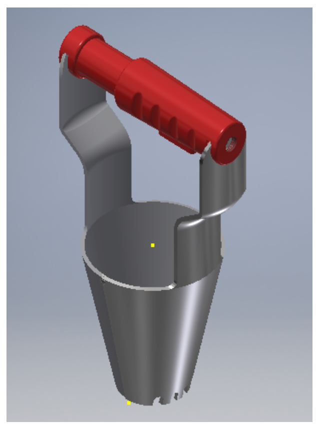

Figure 4: Design Concept 4

For the fourth design (see in Figure 4 is final design, unlike the preceding design, where the mini holder shovels are changed, the design of support changed to make it strong, the basic design of the shovel is converted into a 35-degree angle to give a powerful link to link the ground.

Design changes are frequently encountered in the product development process. The complexity of the design changes is multiplied when the product design involves multiple engineering disciplines. Very often, a simple change in any part may propagate to its neighboring parts, therefore, affects the entire product assembly. Both parts and assembly must be regenerated for a physically valid product model, at the same time, the regenerated product model must meet designer's expectation.

By using Autodesk Inventor, it can design and analysis in one time, which it makes user easy to use it. When a product is being developed in a Concurrent Design and Manufacturing (CDM) environment, the design changes are usually implemented first by altering the geometry of the product represented in computer-aided design (CAD) solid models. If the product solid model is not parameterized properly, the changes in geometry often lead to invalid parts or assembly. At the part level, the changes may yield a solid model with invalid geometric features if it is not properly parameterized. In this case, the entire product assembly is in vain. Even when individual parts of the product are regenerated correctly, parts may still penetrate to 29.

By comparing these scalar quantities, it is possible to judge the convergence of the solution with respect to mesh refinement. After comparing a minimum of three successive solutions, an asymptotic behaviour of the solution starts to emerge, and the changes in the solution between meshes become smaller. Eventually, these changes will be small enough that the analyst can consider the model to be converged. This is always a judgment call on the part of the analyst, who knows the uncertainties in the model inputs and the acceptable uncertainty in the results.

The algorithms used to generate the meshes themselves are also continuously improving and taking greater advantage of multicore computing. Additionally, the 32 solvers are becoming more efficient, with the ability to solve huge models on cluster computers. All of these changes will provide more accurate solutions in less time, while accelerating the analysis and design process.

By using Finite Element Analysis (FEA) to analyse the product design, these three elements need to be emphasized such as Von Mises Stress, displacement and safety factor while three materials used for shovel's design analysis are steel, mild steel and alloy steel. Their mechanical properties as per Table 1.

Table 1: Comparison Mechanical Properties of Materials

Properties/Material	**Steel**	**Mild Steel**	**Alloy Steel**
Density (1000kg/m^3)	7.80-8.00	7.86	7.85
Modulus of Elasticity (GPa)	200	205	190-210
Tensile strength (MPa)	420	400	758-1881
Yield Strength (MPa)	350	250	366-1793
Brinell No.	121	130	149-627

3.0 RESULTS AND DISCUSSION

For analysis, 700 Newton was applied on product for testing the analysis by using Finite Element Analysis (FEA) in Autodesk Inventor software. There were three elements need to be studied in materials product which were Von Mises Stress, displacement, and safety factor in three materials. Three materials used for analysis are steel, mild steel and alloy steel.

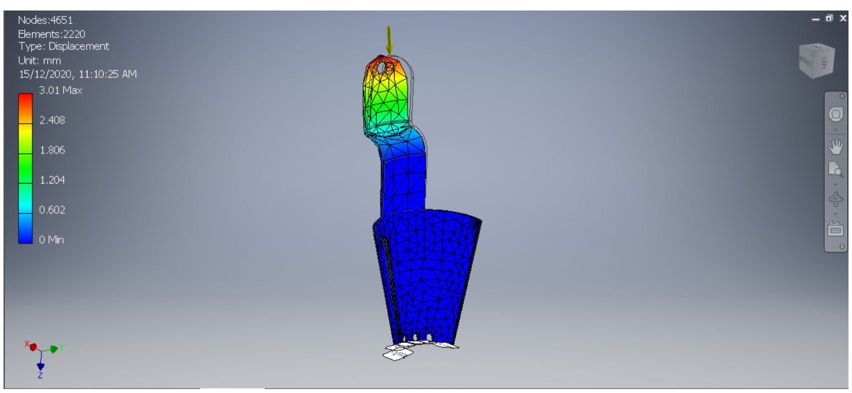

Figure 5: Displacement of Steel.

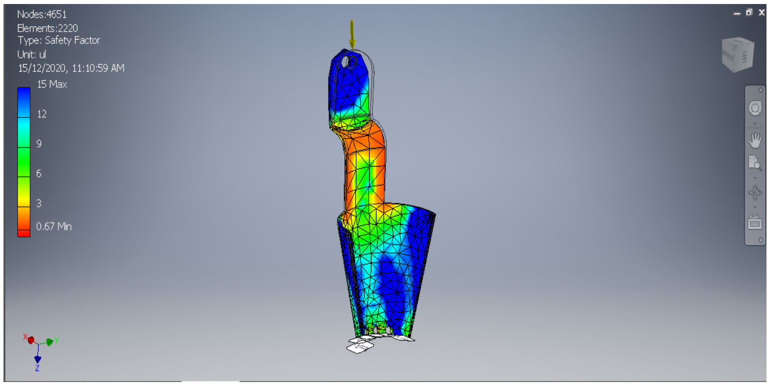

Figure 6: Safety Factor of Steel.

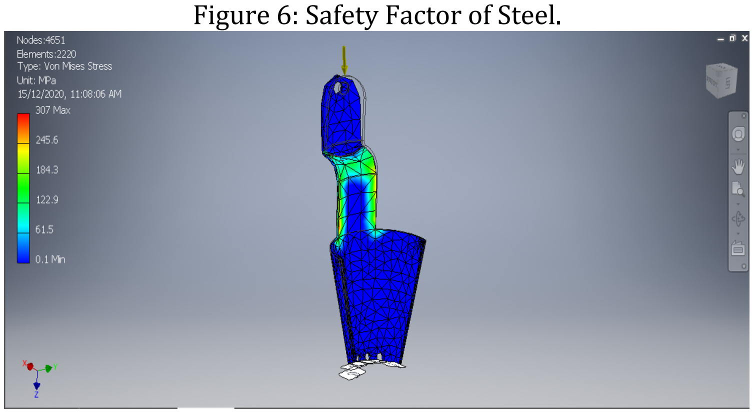

Figure 7: Von Mises Stress of Steel.

Figure 5, Figure 6 and Figure 7 simulate value 307 MPa for Von Mises Stress, 3.01mm for displacement and 15 for safety factor respectively for analysis using steel material. Compared to mils steel and alloy steel, the findings as per Table 2 shows steel material is more suitable shovel's material.

Table 2: Summary of FEA for Different Materials

Material/ Value	**Von Misses Stress/ MPa**	**Displacement/ mm**	**Safety Factor**
Steel	307.0	3.010	15
Mild Steel	307.8	2.889	15
Alloy Steel	30.6.1	9.106	15

4.0 CONCLUSION

In this paper, the authors have design a mini transplanting shovel using Autodesk Inventor 2019 as 3D CAD software then proceed with analyse using Finite Element Analysis (FEA) to determine Von Mises Stress, displacement and safety factor for innovate shovel design. Out of four (4) design with three (3) different materials, design 4 is more suitable and applicable for shovel due to its high Von Mises Stress and displacement values. It can be concluded that this innovative design of shovel is more durable, user friendly, functional and practical compared to conventional design of shovel.

ACKNOWLEDGEMENT

The authors gratefully acknowledge the technical support of Faculty of Engineering Technology, Manufacturing Department at UC TATI, Terengganu, Malaysia.

REFERENCES

Adams, Chris. "Ergonomics." ThoughtCo, Feb. 11, 2020, thoughtco.com/ergonomicsmeaning-1206557.

A. Inbasekaran et al, (2020). Design and Modification of Shovel in Five Tyne Cultivator using Finite Element Analysis.

A Nazri and M S M Sani, Finite Element Normal Mode Analysis of Resistance Welding Jointed of Dissimilar Plate Hat Structure (2017), IOP Conf. Ser.:Mater. Sci. Eng. 257 012059.

Luna, M.A., Sarkar, M.A.R., Uddin, M.R., and Sarker, U.K. (2017). Effect of age of seedlings at staggered planting and nitrogen rate on the growth and yield of transplant Aman rice. Journal of Bangladesh Agricultural University, 15(1), 21–25.

Marzia, R., Sarkar, M.A.R., and Paul, S.K. (2016). Effect of row arrangement and integrated nutrient management on the yield of aromatic fine rice (cv. BRRI dhan34). International Journal of Plant & Soil Science, 13(5), 1-8.

M.H.N. Izham, N.A.Z. Abdullah, S.N. Zahari and M.S.M. Sani, Structural Dynamic Investigation of Frame Structure With Bolted Joints (2017), DOI: 10.1051/ matecconf/20179001043.

M.S.M. Sani et al 2017 IOP Conf. Ser.: Mater. Sci. Eng. 238 012017, Vibration Analysis of Resistance Spot Welding Joint for Dissimilar Plate Structure (Mild Steel 1010 and Stainless Steel 304).

M.S.M. Sani, N.A.Nazri, S.N.Zahari, N.A.Z. Abdullah, G.Priyandoko, Dynamic Study of Bicycle Frame Structure (2016), IOP Conf. Ser.: Mater. Sci. Eng. 160 012009.

N.A.Z. Abdullah, M.S.M. Sani, N.A. Husain, M.M. Rahman and I. Zaman, DOI: 10.15282/ijame.14.1.2017.6.0316, March 2017, Dynamics Properties of a Go Kart Chassis Structure and Its Prediction Improvement Using Model Updating Approach. 46

Pal, S., Paul, S.K., Sarkar, M.A.R., and Gupta, D.R. (2016). Response on yield and protein content of fine aromatic rice varieties to integrated use of cowdung and inorganic fertilizers. Journal of Crop and Weed, 12 (1), 1-6.

Ray, S., Sarkar, M.A.R., Paul, S.K., Islam, A.K.M.M., and Yeasmin, S. (2015). Variation of growth, yield and protein content of transplant Aman rice by three agronomic practices. Agricultural and Biological Sciences Journal, 1 (4), 167-176.

Roy, B., Sarkar, M.A.R., and Paul, S.K. (2015). Effect of integrated nutrient.

Siti Norazila Zaharia, Mohd Shahrir Mohd Sania, Nurulakmar Abu Husainb, Mahadzir Ishakc, Izzuddin Zamand, Dynamic Analysis of Friction Stir Welding Joints In Dissimilar Material Plate Structure (January 2016), DOI: 10.11113/jt.v78.9148.

Summers, P.T., Chen, Y., Rippe, C.M. et al. Overview of aluminum alloy mechanical properties during and after fires. Fire Sci Rev 4, 3 (2015). https://doi.org/10.1186/s40038-015-0007-5

S. V. Doronin and Yu. F. Filippova, (2017). Designs of Mining Shovels with Digging Equipment of Nonclassical Structural Layout.

Wang M., Wang Q., Zhang B. (2019) A Grafting Technique for Efficiently Transplanting Transgenic Regenerated Plants of Cotton. In: Zhang B. (eds) Transgenic Cotton. Methods in Molecular Biology, vol 1902. Humana Press, New York, NY. https://doi.org/10.1007/978-1-4939-8952-2_16