DEVELOPMENT OF A REMOTE-CONTROL ELECTRIC MOWER

Mohd Khairi Mohamed Nor[1], Shamsul Anuar Shamsudin[2], Raja Nor Firdaus Kashfi Raja Othman[1], Mohamad Hanif Sallehuddin[2], Wan Mohd Zailimi Wan Zakaria @ Abdullah[2], Nur Latif Azyze Mohd Shaari Azyze[1], and Mohd Sharieel Mohd Aras[1]

[1]Fakulti Teknologi dan Kejuruteraan Elektrik,
Universiti Teknikal Malaysia Melaka (UTeM), Hang Tuah Jaya, 76100 Durian Tunggal, Melaka, Malaysia.

[2]Fakulti Teknologi dan Kejuruteraan Mekanikal,
Universiti Teknikal Malaysia Melaka (UTeM), Hang Tuah Jaya, 75450 Ayer Keroh, Melaka, Malaysia.

*Corresponding Author's Email: shamanuar@utem.edu.my

Article History: Received xxxxx; Revised xxxx; Accepted xxxx

ABSTRACT: There are green areas in UTeM, not only along the road but also around the lake area as well as around buildings. The grass area covers flat terrain, slope, and banks throughout the campus. This is going to take time to cut all the grass on the campus. Nevertheless, grass cutting work is risky and it involves working long hours under the sun in an open area. Because of that, local people are less interested in doing them and foreign workers would have to be employed instead. The COVID-19 pandemic that hit the nation and worldwide made the situation worse. Due to travel restrictions in most countries, foreign workers could not come to Malaysia to work. Hence, this project will involve the process of design and fabrication of a mobile machine that can cut grass along the UTeM's green areas. In phase one, the project focuses on gathering information and relevant data from various sources and study. In this phase several conceptual designs were proposed and only one is selected to meet the customer requirements. Phase two involves preparing computer models and studying strength analyses using Finite Element Analysis (FEA). At this stage, the engineering drawings and detailed product design specifications are going to be finalized. Phase 3, the completed prototype is going to be tested in field tests to ensure that the prototype can function as designed.

KEYWORDS: *Grass-cutter, structure, stress-analysis, lawn mower, remote control.*

1.0 INTRODUCTION

For many years manual labor has been used to do many chores and maintenance activities along the roads at UTeM including grass cutting. As shown in Figure 1, the green area at UTeM not only along the roads but it covers the lake area and building area. The green area is also not only flat terrain but also covered the slope and banks along the lake. This means that it takes time to cut all the grass in this area and dangerous to the worker. This is good for job creation for the people. Nevertheless, these jobs are risky and involve working long hours under the sun in an open area. Because of that, local people are less interested in doing them and foreign workers would have to be employed instead. The COVID-19 pandemic that has hit the nation and worldwide is making the situation worse. Due to travel restrictions for some country, foreign worker cannot come to Malaysia to work. It makes our country lack workers, especially in labor jobs like grass cutting.

Figure 1: The vast lawn on UTeM main campus.

2.0 BACKGROUND STUDY & METHODS

Hence, the project will involve process of design and fabrication of a mobile machine that can be used to cut grass along the UTeM`s green area. Figure 2 shows some of the mower types already available for industrial applications [1]. We can divide the use of the mower-based terrain and plant type. The wheel type mower and track type mower are the most suitable machines that can be used for areas from fields to natural slopes. As shown in Table 1, we try to benchmark the existing product with wheel and track machine. From Table 1 the, we can say that most of the current products are using engines as their power source. The machines also used various types of blade systems where the type of the system is good for grass cutting. The machine will use remote control unit for maneuvering during operation. Prices varied from RM 80,000 to RM 210,000.

Figure 2: A remote-controlled grass cutter [2].

Table 1: Comparison among similar mowers in the market

		
RM 207,626.13	RM 80,523.05	RM 119,866.47
Agria 9600 Mower [3]	Spider cross liner mower [4]	AS940 Sherpa Mower [5]
Kawasaki FS730 V	Kawasaki FS730 V	Briggs & Stratton
Remote radio controller	Remote radio controller	Remote radio controller
2 swivel blades with 4 swivels.	Four-blade, fixed blades.	cross-blade.

The engineering design methods in [6] will be applied in this project. We divide the process of development into three phases. In phase one, the project will focus on gathering information and relevant data from various sources and study. Quality Function Deployment (QFD) method is applied to translate customer requirements into technical specifications as a basis for the new product development. This phase also proposed several conceptual designs to be selected to meet the customer requirements and benchmarking. Phase 2 focuses in preparing the computer-aided design (CAD) model and applying strength analysis using Finite Element Analysis (FEA). At this stage, the engineering drawing and details product design specification are going to be finalized. Phase 3, the completed prototype is going to be tested in field tests to ensure that the prototype can function as designed. Not only that the functionality of the machine will be analyzed but the customer experience will be studied through product market survey which will lead to better remote-control design and development that is able to match current products in the market. The plan is to produce one unit of this UTeM Smart Mobile Grass Cutter. The other smart aspect of the machine is the availability of data through the Internet of Things (IoT) scheme to remotely supply information like productivity, live tracking, as well as vital signs of the mower like battery or fuel level, temperature, and speed. The UTeM smart grass cutter will become a one of technological showcases for UTeM in using advanced technology that not only benefits UTeM but also community and the country.

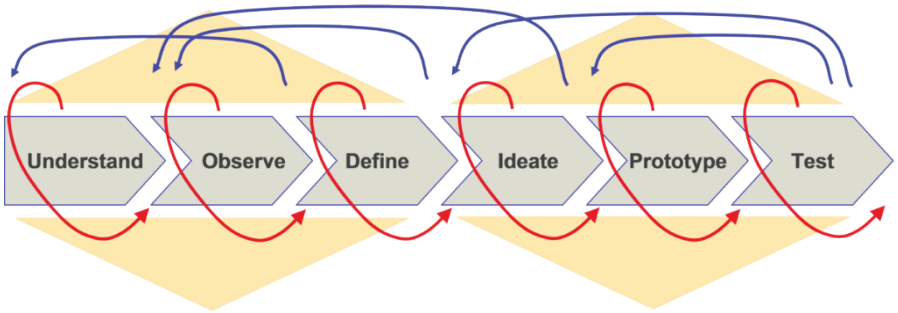

Figure 3: The Design Thinking Process [7].

Product design takes a long time and a great deal of effort. It is important to target the project to minimize time and costs and to plan for it to be successfully completed within allocated resources. Time is very much of the essence, the minimum compatible with optimal development. The engineering design methods in [6] were applied in this project. Figure 3 displays a design flow in general. The process in this project is divided into three phases. In phase one, we will focus on the development of conceptual design of the machine based on the information from UTeM`s Development Office and relevant information from various resources. Market survey and online research on various designs or patents also will be done. To generate the conceptual design, Quality Function Deployment (QFD) method will be employed to understand. QFD is a structured method that uses the seven management and planning tools to identify and prioritize customers' expectations quickly and effectively.

3.0 RESULTS

The final design drawing, exemplifying the application of these principles, was generated using SolidWorks software. The drawing can be observed in Figure 4.

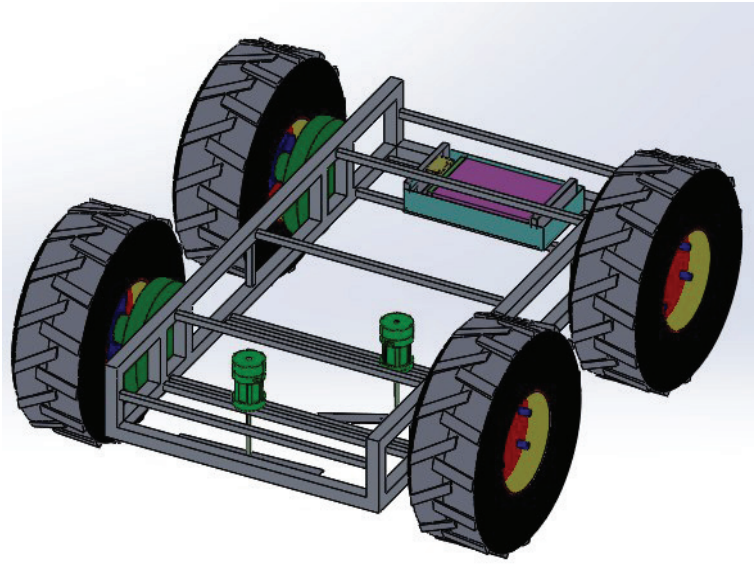

Figure 4: The early frame design of the mower [8].

SolidWorks Simulation is a virtual testing environment that facilitates design analysis, performance evaluation, and decision-making to enhance product quality. It offers an intuitive platform for simulating linear statics, time-based motion, and fatigue analysis, enabling engineers to assess single body parts under simple loads and supports [9]. Employing the Finite Element Analysis (FEA) numerical technique, SolidWorks Simulation predicts real-world physical behavior by virtually testing CAD models.

FEA has revolutionized virtual simulation technology, enabling the examination of product designs' responses to various physical effects, such as bending, heat, vibration, fluid flow, and impacts [10]. For the specific case of the self-reeling hose mechanism, the simulation focuses on three crucial parts: the main body frame, the starter rewind spring, and the ratchet and pawl. These components were selected due to their criticality in the mechanism's operation, as they experience significant loads. By calculating the factor of safety and identifying potential causes of premature failure, early design evaluations can be conducted within the design cycle. Figure 5 shows the displacement when 30 N forces are used for the two cutters in the front portion while 50 N weight was considered for the battery pack at the back. The supports are at the screw holes for the wheels.

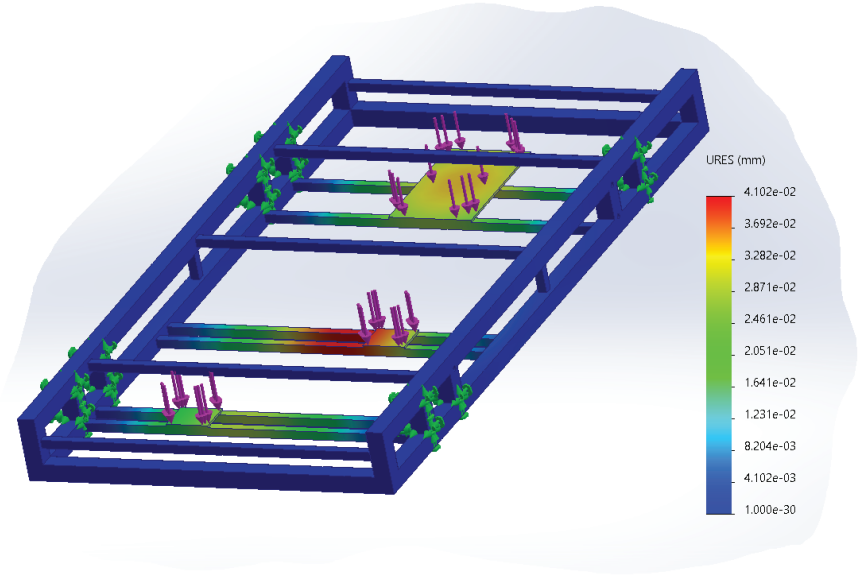

Figure 5: The displacement results from FEA.

Since the results show that the maximum displacement of 0.041 mm in this static stress analysis. Meanwhile, Figure 6 exhibits that the maximum von Mises stress is found to be 1.798 MPa. Since 1060 Aluminum Alloy has a yield strength of about 27.6 MPa, the factor of safety is 15.35, which is rather large.

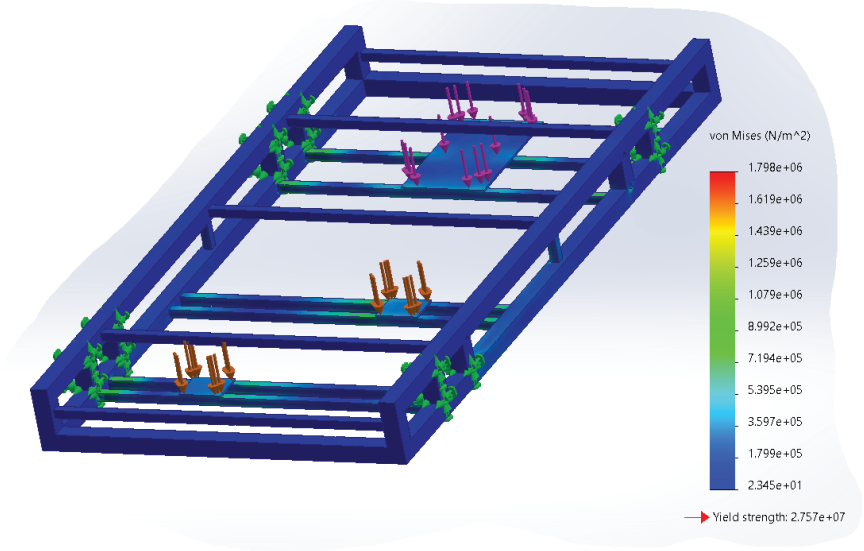

Figure 6: The von Mises stress result from FEA.

Further development in this work has led to another design. The new frame is shown in Figure 7.

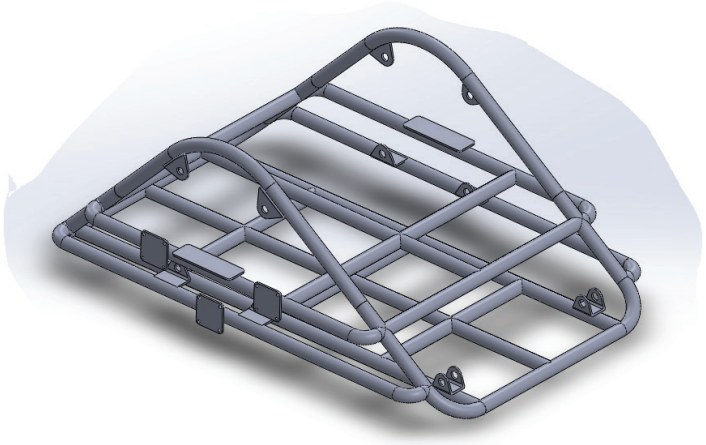

Figure 7: The latest structure for the mower.

4.0 CONCLUSION

The objective to develop UTeM Smart Grass Cutter has almost been achieved. A sturdy frame has been designed and analyzed to produce a good result. The project will be completed when the other systems like the controls, electric motors, cutters, and batteries are integrated by August 2024. Soon, this machine will be tested to see its efficiency and to solve problems that might arise.

ACKNOWLEDGMENTS

The authors would like to thank the Deputy Vice-Chancellor (Research and Innovation) and the Center for Research Management (CRIM) for granting and supporting the RM 80,000 special allocation under PJP/2023/TD/FKM/S01981.

REFERENCES

[1] What is the best commercial mower for your situation, https://www.civiline.com.au/Civiline/Roadmap.php?brand=Civiline&title=Technology_Roadmap, August 19, 2022.

[2] Caroline. https://commons.wikimedia.org/wiki/File:RoboFlail_remote-controlled_mower.jpg, 2011.

[3] Robot lawn mower brush cutter RS Agria 9600 (Official Distributor), https://intermaquinas.online/en/producto/robot-cortacesped-desbrozadora-rs-agria-9600-112/, August 19, 2022

[4] Commercial Lawn Mower: SPIDER CROSS LINER: SPIDER Mowers, https://spidermowerusa.com/products/spider-crossliner/, August 19, 2022.

[5] AS 940 Sherpa 4WD XL, http://www.hening.com.my/v1/product/as-940-sherpa-4wd-xl/, August 19, 2022

[6] G. E. Dieter and L. C. Schmidt. Engineering design. Boston: McGraw-Hill Higher Education, 2009.

[7] A. Ninck. Design Thinking Flow Diagram. Sourced from https://en.wikiversity.org/wiki/File:Design_thinking.png, 2010.

[8] Mohamad Hanif Sallehuddin. Development of a Lightweight Structure for an Electric Grass Cutter. Final Year Project Report, BEng Mechanical Engineering, Universiti Teknikal Malaysia Melaka, 2023.

[9] J. Stiehm. SolidWorks Simulation 2019: A Power Guide for Beginners and Intermediate Users. CreateSpace Independent Publishing Platform, 2019.

[10] R. Erickson. SolidWorks Simulation 2019 Black Book. CreateSpace Independent Publishing Platform, 2019.