ISSN 2087-3336 (Print) | 2721-4729 (Online)

TEKNOSAINS: Jurnal Sains, Teknologi dan Informatika
Vol. 13, No. 1, 2026, page. 89-97
http://jurnal.sttmcileungsi.ac.id/index.php/tekno
https://doi.org/10.37373/tekno.v13i1

Design and structural analysis of a 100 kg/h palm frond shaving machine using SolidWorks

Dicky Septri Anugrah[1], Achmad Jusuf Zulfikar[1*], Ibnu Hajar[2], Suardi[3]

[1*]Universitas Medan Area, Indonesia, Jl. Kolam No. 1 Medan Estate, Medan, Indonesia
[2]Politeknik Negeri Bengkalis, Riau, Indonesia, Jl. Bathin Alam, Sungai Alam, Bengkalis, Riau, Indonesia
[3]Universitas Tjut Nyak Dhien, Medan, Indonesia, Gg. Rasmi No.28, Sei Sikambing C. II, Medan, Indonesia

[*]Corresponding Author: zulfikar@staff.uma.ac.id

Submitted: 1/7/2025 Revised: 28/7/2025 Accepted: 7/8/2025

ABSTRACT

This study presents the design and structural analysis of a palm frond shaving machine with a production capacity of 100 kg/hour, aimed at improving the efficiency of the traditional manual process used by craftsmen. The manual method is time-consuming and labor-intensive, limiting production to approximately 2 kg/hour. To address this issue, a mechanical design was developed using SolidWorks 2017 software. The research involved consumer surveys to identify user requirements, followed by concept generation, technical and economic evaluation, and simulation analysis of the selected design. Among three design variants, the second concept—featuring a stone grinder cutter system, UNP steel frame, V-belt transmission, and gasoline engine—was selected as optimal based on combined technical and economic scores. Structural simulation results indicate that the frame, made from UNP 50 steel profiles, exhibits acceptable stress, displacement, and safety factor levels under an applied load of 10 kg. This study offers a viable solution for small-scale industries to process palm fronds into usable sticks efficiently. Future work may include prototype development and extended performance testing. The machine's application is expected to contribute to local economies by utilizing agricultural waste and increasing the production of palm stick-based handicrafts.

Keywords: Palm frond; shaving machine; Solidworks; structural analysis; small-scale industry

1. Introduction

Palm oil (Elaeis guineensis Jacq.) is a key agricultural commodity in tropical countries, widely cultivated due to its high economic value [1], [2]. Besides its fruits being processed into oil, other parts of the palm trees, such as fronds, trunks, and empty bunches, are also valuable by-products [3]. Palm fronds contain central ribs or "sticks" (lidi) that can be extracted and processed into various handicrafts, such as brooms or woven goods. Currently, artisans manually cut palm leaves to isolate these sticks using knives—a labor-intensive and inefficient process that limits productivity. This challenge necessitates the development of a mechanical system that can increase production speed while reducing physical strain and variability in product quality [4]. With increasing market demand for palm stick-based crafts, especially in both domestic and export markets, a specialized machine that can process palm fronds efficiently and affordably would be highly beneficial for small and medium enterprises (SMEs). Therefore, the development of a palm frond shaving machine using computer-aided design tools is essential to bridge this technological gap and promote sustainable utilization of agricultural by-products.

Previous studies have highlighted the versatility of palm fronds and the growing need for efficient processing equipment [5]. Designed a palm frond peeler using rollers as extractors, while explored the use of CAD-based design to optimize palm frond waste processing tools. These studies demonstrate the potential for palm frond mechanization in reducing labor and increasing productivity [6]. The use of SolidWorks in mechanical design and simulation further supports the importance of integrating modern engineering tools into agricultural machinery design. SolidWorks provides 3D modeling and simulation capabilities, enabling the evaluation of stress, displacement, and factor of safety (FOS) before physical prototyping. These capabilities were crucial in evaluating various design concepts in this study [7]. However, most existing machines do not prioritize lightweight structures, user-friendly interfaces, or cost-effective solutions for small-scale users. This research contributes to existing literature by combining user needs assessment with technical and economic evaluation through simulation-based analysis to identify the most practical and efficient design for palm frond shaving applications [8].

The novelty of this research lies in its integrative approach combining consumer-driven design, technical evaluation, economic feasibility, and structural simulation into a unified framework using SolidWorks [9]–[11]. Unlike previous studies that either focus solely on the mechanical function or economic justification of palm frond processing machines, this study proposes three alternative designs and systematically selects the best variant based on a weighted scoring method [12][13][14]. The selected design utilizes a stone grinder mechanism for optimal frond separation, UNP steel frame for durability, and gasoline engine power for off-grid usability. Structural performance was validated through Finite Element Analysis (FEA), assessing Von Mises stress, displacement, and factor of safety (FOS), thereby ensuring that the machine is not only functional but also structurally reliable under operational loads [15][16]. Furthermore, this research emphasizes practical application by targeting a production rate of 100 kg/hour, addressing a critical bottleneck in artisanal palm stick production [17][18]. The combination of low-cost materials, simple operation, and simulation-verified reliability makes this machine design particularly suitable for rural microenterprises and home industries, contributing to sustainable development and waste valorization in palm oil-producing regions [19]–[21].

The primary objective of this study is to design a palm frond shaving machine that meets the practical needs of palm stick craftsmen by significantly enhancing the efficiency, productivity, and ergonomics of the frond processing process [22]. This research aims to translate user requirements into viable engineering solutions by developing three alternative design concepts and evaluating them based on technical performance and economic feasibility. Through a structured assessment approach involving user surveys and weighted scoring, the study seeks to determine the most effective design variant. The chosen design is further analyzed using SolidWorks simulation tools to evaluate structural integrity under operational loads, including parameters such as Von Mises stress, displacement, and safety factor. By integrating user-centered design and engineering simulation, this research contributes to the development of a reliable, safe, and economically feasible machine that can be implemented in rural or small-scale industries. The ultimate goal is to support local palm frond-based production activities, promote sustainable waste utilization, and provide a scalable solution for improving artisan productivity.

2. Method

The research was conducted at the Mechanical Engineering Workshop of Universitas Medan Area. The study began in August 2022 and extended until the project completion phase in early 2025. Activities included preliminary surveys, design modeling, simulation, and final reporting. The primary tools used were SolidWorks 2017 for 3D modeling and structural analysis, along with standard computing equipment. The research followed a sequential process involving literature review, consumer interviews, variant generation, performance simulation, and final evaluation.

The tools used in this study included a laptop computer equipped with SolidWorks 2017 software for 3D modeling and structural analysis. The primary material was survey data obtained from interviews with 10 palm frond artisans, which formed the foundation for user-centered design. Conceptual drawings and simulations were built using standard UNP 50 steel profiles as the frame material, assuming static loads up to 10 kg. The software enabled modeling of mechanical elements such as cutting tools (steel partition, stone grinder, coconut peeler), transmission (V-belt and pulley), and power systems (gasoline and electric motors).

The procedure of this study followed a systematic sequence of design and analysis stages aimed at developing a functional palm frond shaving machine. Initially, a field survey was conducted involving ten local craftsmen to gather qualitative insights regarding their current practices, challenges faced, and expectations for a mechanical solution. Based on the survey results, three conceptual design variants were developed, each differing in cutting mechanisms and drive systems. These concepts included a steel partition blade system (VK1), a stone grinder system (VK2), and a coconut scraper mechanism (VK3). Using SolidWorks 2017, all designs were modeled in 3D, incorporating critical components such as the frame, transmission system, and cutting units. Each concept was then assessed using a weighted scoring system based on technical criteria functionality, durability, ease of assembly and economic factors material cost, component simplicity, and manufacturability. Concept 2 (VK2) emerged as the optimal solution, having achieved the highest combined score. Following this, a structural simulation of the selected design was conducted using Finite Element Analysis (FEA) to evaluate stress distribution, displacement, and factor of safety under a simulated 10 kg load. The validated simulation results confirmed that the design met mechanical safety standards and was ready for further prototyping and field application.

The structural analysis in this study employed several fundamental mechanical engineering formulas to assess the performance and safety of the palm frond shaving machine frame. These formulas were integrated into the Finite Element Analysis (FEA) environment of SolidWorks to evaluate stress, displacement, and safety under operational loads. The primary parameter analyzed was the normal stress acting on the frame, which is determined by the ratio of the applied force to the cross-sectional area, as given in Equation (1) [23], [24].

$$\sigma = \frac{F}{A} \tag{1}$$

Where σ is the stress (in N/m²), F is the applied force (in Newtons), and A is the cross-sectional area (in m²). To assess material failure under complex loading conditions, the Von Mises stress criterion was used. This approach predicts the yielding of ductile materials and is essential in evaluating whether the frame can safely withstand the applied loads. The displacement of the structure under load was estimated using the standard deflection formula for beams under static loads, shown in Equation (2) [25][26].

$$\delta = \frac{FL^3}{3EI} \tag{2}$$

In this equation, δ is the deflection (in meters), L is the length of the beam (in meters), E is the modulus of elasticity (in N/m²), and I is the moment of inertia (in m⁴). Finally, the safety factor (FoS), which indicates the structural reliability of the frame under loading conditions, was calculated using Equation (3) [27], [28].

$$\text{FoS} = \frac{\sigma_{yiled}}{\sigma_{max}} \tag{3}$$

Where σ yield is the yield strength of the material and σ max is the maximum stress obtained from the simulation. A safety factor greater than 1.5 was targeted to ensure structural reliability. These formulas formed the basis of the structural assessment, validating that the machine design can operate under intended loading conditions without risk of failure.

3. Result and Discussion

The initial phase of the results involved identifying user needs through a field survey targeting ten palm stick craftsmen. The survey revealed that traditional methods for shaving palm fronds—typically using knives—yielded only about 2 kg per hour, leading to low productivity and high labor demands. All respondents expressed a need for a machine that could increase output while reducing physical effort. Based on this data, three conceptual design variants were developed. Each variant differed in its cutting mechanism, transmission system, and power source. Variant 1 (VK1) used a steel blade, Variant 2 (VK2) implemented a stone grinder, and Variant 3 (VK3) featured a coconut scraper mechanism. Technical and economic criteria were then applied to evaluate each design. Figure 1 and Figure 2 in the original document display comparative bar charts illustrating the technical and economic scores of each variant. VK2 consistently outperformed others with a technical score of 365 and an economic score of 300, leading to a combined score of 665 as shown in Table 1. These evaluations confirmed VK2 as the most efficient and practical design for production purposes.

The selected VK2 design was further modeled in SolidWorks 2017 to conduct structural analysis under simulated working conditions. The frame of the machine was constructed from UNP 50 steel, and the structure was subjected to a 10 kg static load. Structural loading was illustrated in Figure 3, highlighting where the force was applied on the machine's frame. The subsequent Von Mises stress simulation, shown in Figure 4, and Figure 5, revealed that the highest stress concentration was located at the joint between the motor base and the main frame structure. However, the maximum stress value remained well below the yield strength of UNP steel, indicating safe operational conditions. The use of

SolidWorks for simulation enabled accurate visualization of how the machine would perform under real-life scenarios without physically fabricating the prototype, thus saving cost and time in the development process. The stress distribution confirmed that the design was both structurally sound and appropriately optimized for its intended load-bearing applications.

Displacement analysis was also conducted using SolidWorks, with the results presented in Figure 6 and Figure 7. These images illustrate the distribution of deformation across the machine's frame when subjected to the 10 kg load. The maximum observed displacement was within an acceptable range, concentrated around non-load-bearing sections, ensuring that the machine would retain its dimensional stability during operation. Minimal displacement is essential for ensuring that critical mechanical components, such as the grinder and conveyor systems, remain accurately aligned during continuous use. Additionally, these results help confirm that the structural deflections would not affect the cutting precision or operational reliability of the machine. By maintaining structural stiffness, the machine is expected to deliver consistent output quality, which is vital for meeting production targets and minimizing mechanical failures over time. This simulation step was crucial in validating the feasibility of the chosen design prior to fabrication.

Lastly, the Factor of Safety (FoS) analysis provided a quantitative assessment of the machine's reliability under normal operating conditions. Figure 8 and Figure 9 illustrate the FoS simulation results using a color-coded map to display the varying levels of safety across different frame sections. The minimum FoS observed exceeded 1.5 in all areas, with some zones approaching values above 2.0, indicating a high level of structural robustness. This confirms that the VK2 design not only meets minimum safety requirements but also possesses a built-in tolerance for potential load variations or impacts. The evaluation of FoS, in conjunction with stress and displacement simulations, provides a comprehensive understanding of the structural performance of the machine. These results collectively demonstrate that machine design is suitable for real-world implementation. Moreover, the modular use of standardized steel components and belt-driven systems ensures the machine remains easy to fabricate, maintain, and scale for industrial or rural applications. Future development may include field testing, automation enhancements, and multi-size output capability to further improve efficiency and market adaptability.

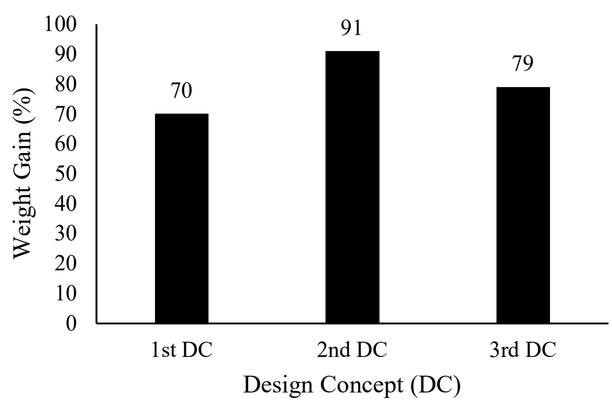

Figure 1. Comparison of design concept variants with technical aspect values

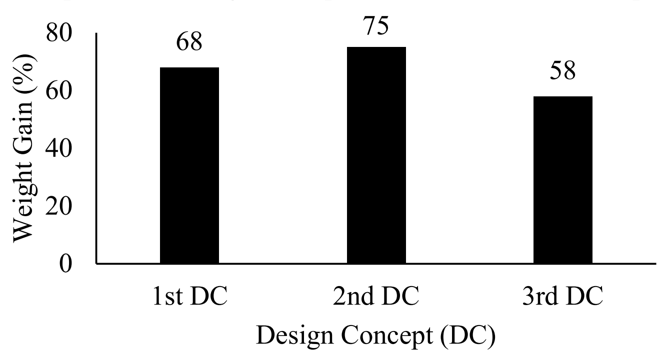

Figure 2. Comparison of design concept variants with economic aspect values

ISSN 2087-3336 (Print) | 2721-4729 (Online)
DOI 10.37373/tekno.v13i1.1755

Table 1. Final assessment of design concept variants

DC	Technical Value	Economic Value	Total Value	Grade
V1	280	270	550	2
V2	365	300	665	1
V3	315	230	545	3

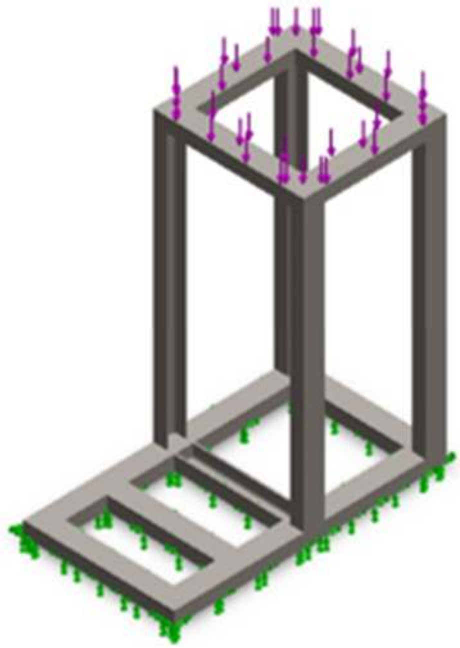

Figure 3. Loading on the structure of the palm kernel shredder

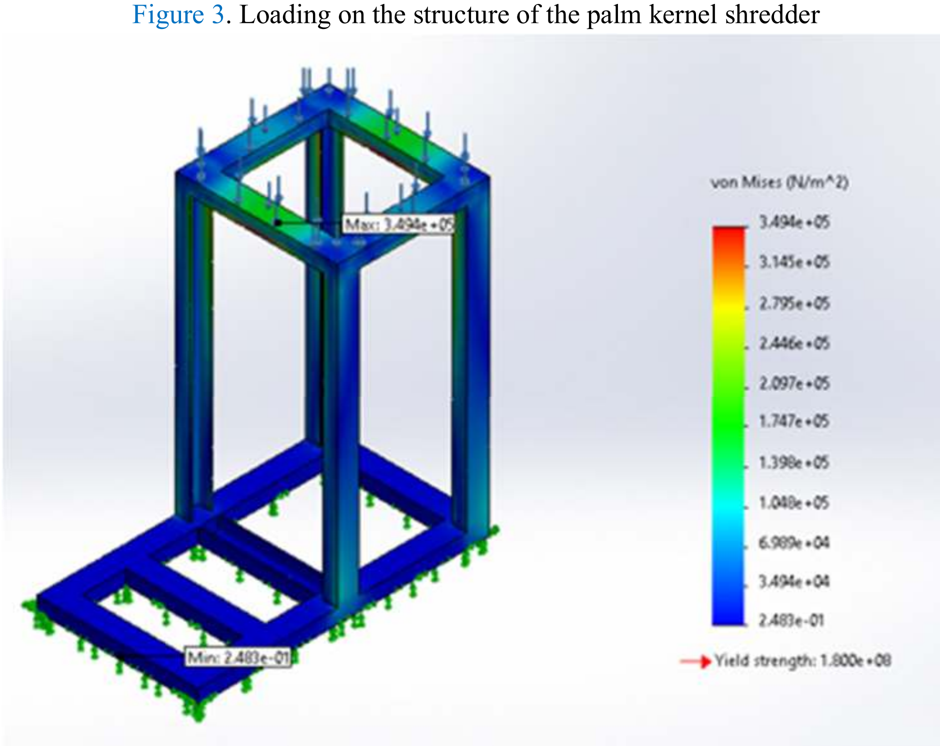

Figure 4. Stress Simulation (Von Mises) In SolidWork Software

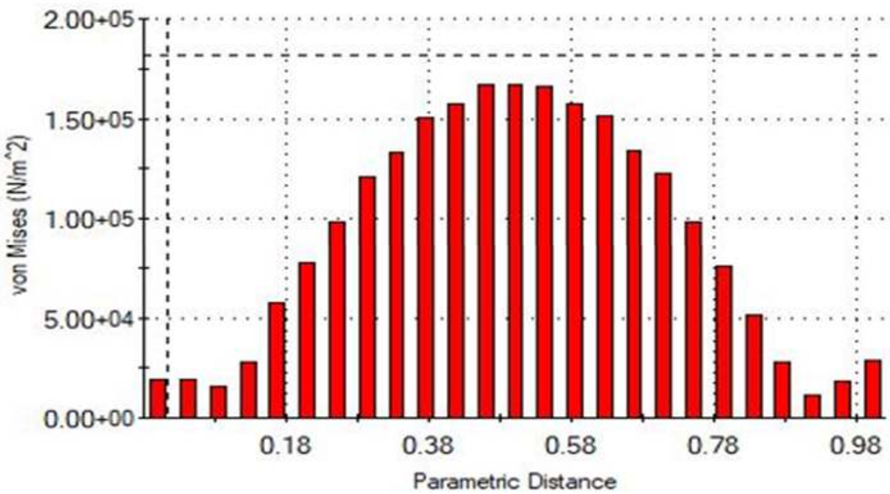

Figure 5. Stress simulation results (Von Mises) in SolidWorks Software

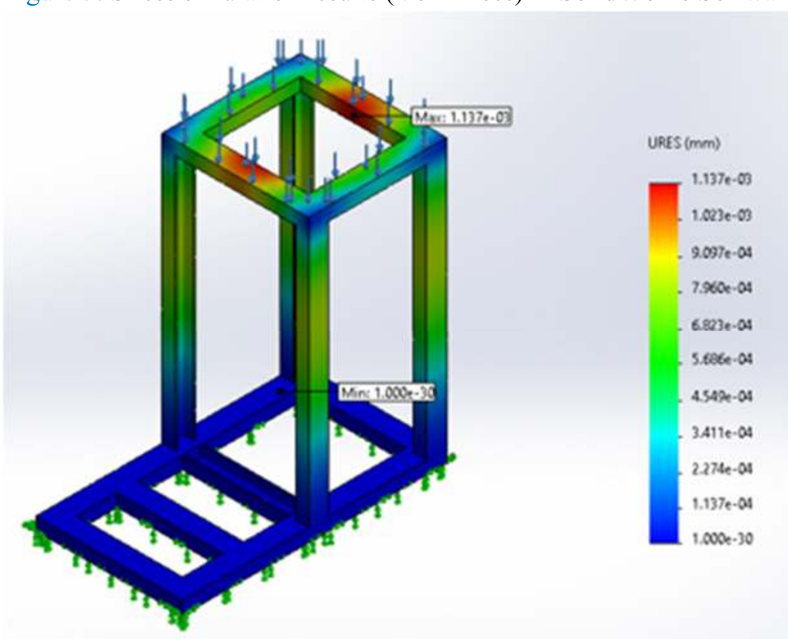

Figure 6. Displacement simulation in SolidWorks Software

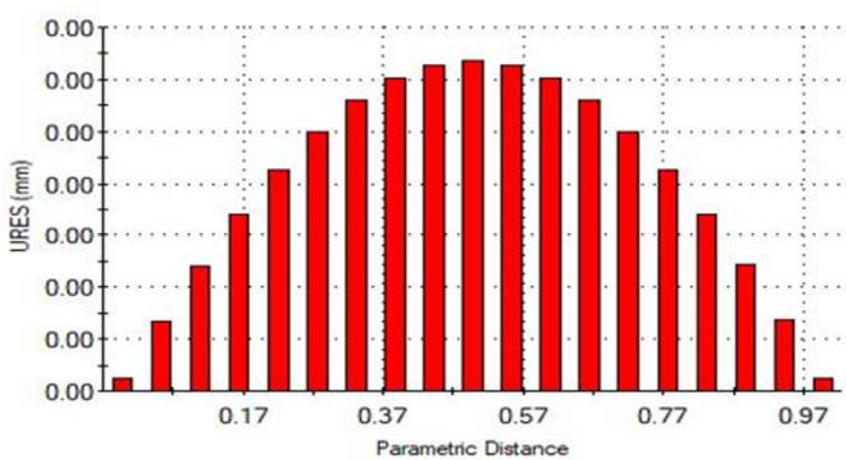

Figure 7. Displacement simulation results in SolidWorks Software

DOI 10.37373/tekno.v13i1.1755

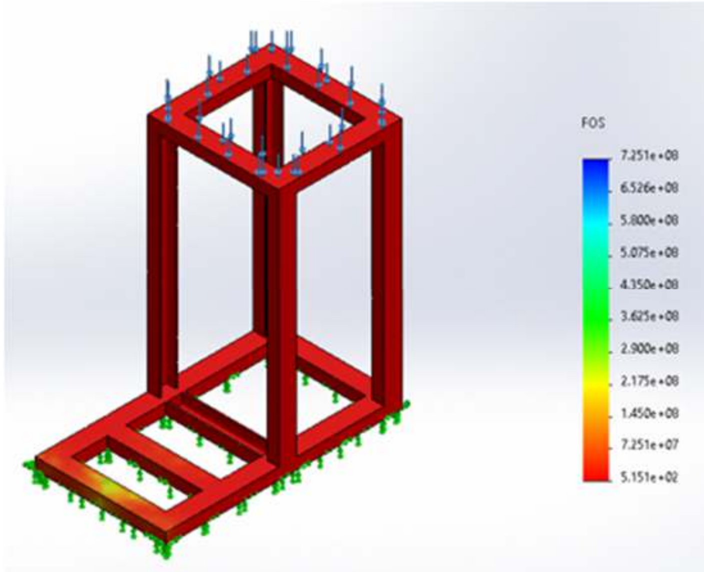

Figure 8. FOS (Factor of Safety) simulation in SolidWorks Software

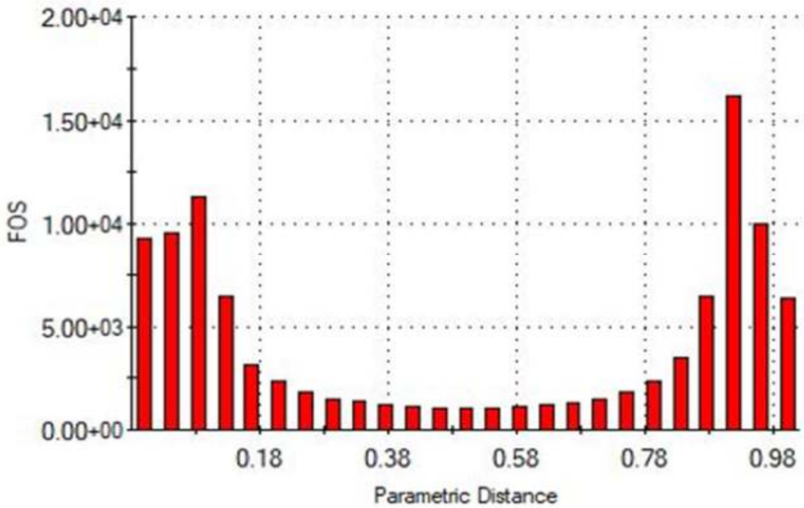

Figure 9. FOS (Factor of Safety) simulation results in SolidWorks Software

4. Conclusion

This study successfully designed and analyzed a palm frond shaving machine capable of producing 100 kg of shaved fronds per hour. Based on surveys and variant evaluations, Concept 2—with its stone grinder mechanism and gasoline engine—was chosen for its superior technical and economic performance. Structural analysis using SolidWorks confirmed the machine's safety under operational load conditions. Von Mises stress remained within the yield strength of UNP steel, displacement was minimal, and the safety factor exceeded recommended thresholds. These results indicate that the machine is feasible for real-world use in palm oil-producing communities. Its simple construction, efficient design, and use of accessible materials make it well-suited for local manufacturing and SME applications. The implementation of such machinery could significantly enhance productivity, reduce labor dependency, and add value to agricultural waste. Future work should include full prototype development, testing under real conditions, and additional features such as automatic feed or multi-size stick output to further improve functionality and market potential.

Acknowledgement

Appreciation to Universitas Medan Area for supporting and facilitating this research so that it can be completed as well as possible.

Reference

[1] S.-C. Chew, Y. How, Z. A. A. Hasan, and C. C. Chu, "Recovery of bioactive compounds from oil palm waste using green extraction techniques and its applications," *Int. J. Food Sci. Technol.*, 2024, doi: 10.1111/ijfs.17572. https://doi.org/10.1111/ijfs.17572

[2] A. M. Alhaji, E. S. Almeida, C. R. Carneiro, C. A. S. da Silva, S. Monteiro, and J. S. D. R. Coimbra, "Palm Oil (Elaeis guineensis): A Journey through Sustainability, Processing, and Utilization," *Foods*, vol. 13, 2024, doi: 10.3390/foods13172814. https://doi.org/10.3390/foods13172814

[3] F. Widyaningsih, R. Irwanto, and D. B. Panjaitan, "CHARACTERIZATION OF OIL PALM SAP (ELAEIS GUINEENSIS JACQ. RESULTS OF ZERO WASTE BASED WASTE TREATMENT)," *J. KESMAS DAN GIZI*, 2023, doi: 10.35451/jkg.v5i2.1403. https://doi.org/10.35451/jkg.v5i2.1403

[4] N. Zainol, A. S. Fakharudin, N. A. Dzulkefli, and M. Bakar, "Multi-objective model optimisation using genetic algorithms for pleurotus sp. cultivation," *IOP Conf. Ser. Mater. Sci. Eng.*, vol. 863, 2020, doi: 10.1088/1757-899X/863/1/012027. https://doi.org/10.1088/1757-899X/863/1/012027

[5] Darwin and Mardhotillah, "Anaerobic Co-Digestion of Oil Palm Frond Waste with Cow Manure for Biogas Production," *Ser. II For. • Wood Ind. • Agric. Food Eng.*, 2021, doi: 10.31926/but.fwiafe.2021.14.63.2.9. https://doi.org/10.31926/but.fwiafe.2021.14.63.2.9

[6] V. Naliapara, V. M. Sejani, and N. U. Joshi, "Design of dry coconut (Cocos nucifera L.) dehusking and deshelling machine components using solidworks simulation," *J. Appl. Hortic.*, 2023, doi: 10.37855/jah.2023.v25i01.18. https://doi.org/10.37855/jah.2023.v25i01.18

[7] O. Petrov, O. Piontkevych, A. Buda, and V. Kolomiiets, "Application of the CAD/CAE system Solidworks in the tasks of analysis of strength of parts of the clamping fixtures," *J. Mech. Eng. Transp.*, 2024, doi: 10.31649/2413-4503-2024-19-1-95-102. https://doi.org/10.31649/2413-4503-2024-19-1-95-102

[8] L. Tarandushka and A. Yovchenko, "Parametric Design of 3D Models of crank Mechanism of a Car with CAD Solidworks," *Cent. Ukr. Sci. Bull. Tech. Sci.*, 2022, doi: 10.32515/2664-262x.2022.5(36).2.195-201. https://doi.org/10.32515/2664-262X.2022.5(36).2.195-201

[9] K. Yevhenii and R. Demchuk, "COMPREHENSIVE REVIEW OF SOLIDWORKS AND ANSYS FOR HYDRAULIC MACHINERY DESIGN AND ANALYSIS," *Bull. Natl. Tech. Univ. "KhPI". Ser. Hydraul. Mach. Hydraul. units*, 2025, doi: 10.20998/2411-3441.2024.2.07. https://doi.org/10.20998/2411-3441.2024.2.07

[10] L. Zheng and Y. Deng, "Research on Case Teaching Based on Solidworks 3D Modeling Course," 2021. https://doi.org/10.12677/AE.2021.116354

[11] M. A. Ruanda, A. J. Zulfikar, and D. A. A. Ritonga, "Numerical simulation and flexural strength analysis of jute / epoxy laminated composites using ANSYS workbench," *JTTM J. Terap. Tek. Mesin*, vol. 6, no. 1, pp. 152–158, 2025, doi: 10.37373/jttm.v6i1.1563. https://doi.org/10.37373/jttm.v6i1.1563

[12] O. E. Itabiyi, K. Adeleke, S. Akangbe, A. Ojetoye, and F. A. Buhari, "Design and Finite Element Analysis of a Thresher for Palm Oil (Elaies guineensis) Extraction Plant," *ABUAD J. Eng. Res. Dev.*, 2024, doi: 10.53982/ajerd.2024.0702.32-j. https://doi.org/10.53982/ajerd.2024.0702.32-j

[13] A. E. Admi, M. A. Sabtu, S. A. Osman, and S. A. Osman, "A Novel Simulation Methodology for Evaluation of Weldment Analysis Tools for Edge Weld Design Optimization," *J. Adv. Res. Appl. Mech.*, 2025, doi: 10.37934/aram.133.1.103119. https://doi.org/10.37934/aram.133.1.103119

[14] A. J. Zulfikar and M. Y. Yakoob, "Hybrid Laminated Composite Casing As Concrete Reinforcement," *Suranaree J. Sci. Technol.*, vol. 30, no. 5, pp. 1–10, 2023, doi: 10.55766/sujst-2023-05-e0870. https://doi.org/10.55766/sujst-2023-05-e0870

[15] A. A. H. Newaz, "Structural Analysis and Design of a Curved Anchor Bracket Using SolidWorks," *Int. J. Sci. Res. Publ.*, 2025, doi: 10.29322/ijsrp.15.01.2025.p15711. https://doi.org/10.29322/IJSRP.15.01.2025.p15711

[16] A. J. Zulfikar, S. Pranoto, D. A. A. Ritonga, J. J. B. B. Butar, and B. O. Simanjuntak, "Efficacy of jute-glass hybrid laminate composite wrapping under flexural loading," *JTTM J. Terap. Tek. Mesin*, vol. 5, no. 2, 2024. https://doi.org/10.37373/jttm.v5i2.1214

[17] Y. M. A. Almashani, A. A. Alamri, M. M. F. Al-Ghassani, and M. V Kulkarni, “STRESS ANALYSIS USING SOLIDWORKS SIMULATION,” *EPRA Int. J. Multidiscip. Res.*, 2023, doi: 10.36713/epra14295. https://doi.org/10.36713/epra14295

[18] M. Y. Yuhazri, A. J. Zulfikar, and A. Ginting, “Fiber Reinforced Polymer Composite as a Strengthening of Concrete Structures: A Review,” *IOP Conf. Ser. Mater. Sci. Eng.*, vol. 1003, no. 1, 2020, doi: 10.1088/1757-899X/1003/1/012135. https://doi.org/10.1088/1757-899X/1003/1/012135

[19] F. Y. Sulistyo, A. Nugroho, and S. Bakhri, “3D Modelling and Static Structural Analysis of Bottom Reflector Experimental Power Reactor (RDE) using Solidworks Software,” *J. Phys. Conf. Ser.*, vol. 1198, 2019, doi: 10.1088/1742-6596/1198/2/022077. https://doi.org/10.1088/1742-6596/1198/2/022077

[20] M. Volpe, L. Rosendahl, S. Ihsan, W. A. Widodo, N. Agus, and A. Saputra, “Utilization of Palm Frond Waste as Fuel for Co-Firing Coal and Biomass in a Tangentially Pulverized Coal Boiler Using Computational Fluid Dynamic Analysis,” *Biomass*, 2024, doi: 10.3390/biomass4040063. https://doi.org/10.3390/biomass4040063

[21] A. J. Zulfikar, Y. Yaakob, H. M. Umarfaruq, and R. Syah, “Natural Jute Laminate for the Improvement of Strength Properties of Concrete Specimen,” *Eng. Trans.*, vol. 71, no. 1, pp. 507–518, 2023, doi: 10.24423/EngTrans.3120.20231017.

[22] H. Sholih, H. T. Saputra, A. Surya, and Wilarso, “Slop piping systems stress analysis using Caesar II software,” in *AIP Conference Proceedings*, 2023, vol. 2706. doi: 10.1063/5.0120759. https://doi.org/10.1063/5.0120759

[23] V. G., S. I., R. K. V S., H. H. V., and S. R. V., “Structural Analysis of the Differential Chassis for Development of Paddy Weeder Using Finite Element Analysis,” *Int. J. Plant Soil Sci.*, 2023, doi: 10.9734/ijpss/2023/v35i224164. https://doi.org/10.9734/ijpss/2023/v35i224164

[24] A. J. Zulfikar, M. Y. Yaakob, and R. Syah, “Application of E-Glass Jute Hybrid Laminate Composite With Curved Shape on Compressive Strength of Cylindrical Column Concrete,” *J. Appl. Eng. Technol. Sci.*, vol. 5, no. 1, pp. 184–196, 2023, doi: 10.37385/jaets.v5i1.2072. https://doi.org/10.37385/jaets.v5i1.2072

[25] O. Giraldo-Londoño and G. Paulino, “A unified approach for topology optimization with local stress constraints considering various failure criteria,” *Proc. R. Soc. A*, vol. 476, 2020, doi: 10.1098/rspa.2019.0861. https://doi.org/10.1098/rspa.2019.0861

[26] A. J. Zulfikar, M. Y. Yuhazri, S. Pranoto, D. A. A. Ritonga, and Z. Husin, “Toughness analysis of jute laminate composites as wrapping for cylindrical concrete columns,” *JTTM J. Terap. Tek. Mesin*, vol. 6, no. 1, pp. 70–76, 2025. https://doi.org/10.37373/jttm.v6i1.1467

[27] A. Mishra, “Role of Reliability Analysis in Structural Design,” *Hydro Nepal J. Water, Energy Environ.*, 2019, doi: 10.3126/HN.V24I0.23574. https://doi.org/10.3126/hn.v24i0.23574

[28] A. J. Zulfikar, D. A. A. Ritonga, A. Purnomo, and T. Erdiansyah, “The Influence of e-glass epoxy composite laminate material application on the crack pattern of cylinder concrete column cross-section,” *J. Terap. Tek. Mesin*, vol. 5, no. 1, pp. 97–104, 2024. https://doi.org/10.37373/jttm.v5i1.889