ISSN 2963-7511
Journal of Engineering Researcher and Lecturer, Vol. 2, No. 2, pp. 50-55, 2023

Finite element analysis of electric motorcycle frame using SolidWorks: A comparative study of circular tube and square tube

Nicolus Obeth Theopilus Simanjuntak[1*], Zeyar Min Thwin Htoo[2] and Mukesh Singh[3]

[1] Department of Mechanical Engineering, Faculty of Engineering, Universitas Negeri Padang, **INDONESIA**
[2] Department of Geomatics, Disaster Mitigation and Management, National Cheng Kung University, **TAIWAN**
[3] Department of Electrical and Instrumentation Engineering, Thapar Institute of Engineering and Technology (Deemed to be University), **INDIA**

Abstract: The frame is one of the critical components of a motorcycle. It needs to be robust, strong, and capable of withstanding various loads such as the engine, body, fuel tank, riders, passengers, and more. Apart from serving as a support for riders, passengers, and cargo, the frame also plays a vital role in connecting the front and rear suspension systems and linking the rear with the front wheel. This research aims to determine the strength of two material profiles, namely circular tube and square tube, in a comparison between AISI 1035 steel (SS) and AISI 1020 for the frame of an electric motorcycle. The comparison is analyzed through simulation results obtained using SolidWorks Research License 2021-2022 with the finite element method. The simulation results reveal that the most suitable profile and material for the frame, characterized by strength, durability, and load-bearing capacity, is the circular tube with AISI 1035 steel (SS). The data shows that the maximum stress occurring after applying the specified load remains within the yield strength of the material. Compared to other profiles and materials, this combination exhibits lower maximum stress, making it a superior choice. This study provides valuable insights into designing a motorcycle frame that can withstand various stresses while ensuring rider safety and optimal performance.

Keywords: Electric motorcycle frame; Solidworks; Circular tube; Square tube, Finite element method

*Corresponding Author: nicolusobeth@gmail.com

Received: May 03rd 2023; Revised: May 26th 2023; Accepted: June 09th 2023
https://doi.org/10.58712/jerel.v2i2.46

Reference to this paper should be made as follows: Simanjuntak, N. O. T., Htoo, Z. M. T., & Singh, M. Finite element analysis of electric motorcycle frame using SolidWorks: A comparative study of circular tube and square tube. *Journal of Engineering Researcher and Lecturer*, 2(2), 50–55. https://doi.org/10.58712/jerel.v2i2.46

1. Introduction

As we are aware, in this modern era, almost all human beings use transportation vehicles without knowing the long-term impacts of their usage (Baboria & Gupta, 2023). In this study, we will discuss one environmentally friendly vehicle, which is the electric motorcycle, as using electric motorcycles is one way to maintain the air quality on Earth. As we know, most vehicles on Earth use oil as their fuel, and excessive oil consumption can damage the ozone layer, leading to global warming and uncontrollable air pollution (Amrullah et al., 2023). Electric vehicles are considered a promising solution to the serious environmental problems caused by fossil fuel-powered vehicles over the past few decades. Global warming and energy crises are major challenges the world is facing due to the increasing population and technological advancements, leading to a rising global demand for energy resources. According to data from BP Statistical Review of World Energy and BP Energy Outlook, oil consumption has grown by 1.9 million barrels per day worldwide, with the majority being used in the automotive industry (Bahulekar & Shinde, 2021). Excessive use of non-renewable resources has severely impacted the environment. The alteration of the natural climate has shown detrimental effects on people's lives. These concerns have made people more conscious of environmental factors and the significance of renewable energy sources. Over the past few years, focus has been on developing vehicles emitting zero or minimal pollutants (Bahulekar & Shinde, 2021; Johny et al., 2021). By using such vehicles, individuals can protect the environment from pollutants like carbon dioxide, carbon monoxide, and various other nitrogen oxides. As stated by Roveda et al., the use of electric vehicles (EVs) with renewable energy sources has significantly reduced greenhouse gas emissions and other pollutants by 40%. Renewable energy sources offer various advantages, including minimal pollution, no fear of depletion, cost-effectiveness compared to other sources, and the potential to boost the nation's economy by creating numerous job opportunities across various sectors (Kondusamy et al., 2021; Mutyala, 2019).

Indeed, the use of electric motorcycles not only helps reduce air pollution but also contributes to alleviating traffic congestion on the roads. As a result, scientists worldwide are focusing on developing eco-friendly transportation options, such as electric motorcycles, where the energy source is electricity. The electric energy is stored in a vital component, the battery, within the vehicle's engine, and is then converted into mechanical energy using the motor. The frame holds utmost significance in electric motorcycles as it provides attachment points for various components such as the battery, lighting system, engine, wheels, braking system, and more (Mutyala, S., & Tech, M., 2019). The electric motorcycle frame is developed by combining elements from traditional motorcycle and bicycle frames (Kurhade et al., 2021). Researchers have been actively involved in the development of electric motorcycle frames by integrating features from standard motorcycle and bicycle frames (Kurhade et al., 2021; Patil et al., 2021). The well-designed frame enhances the riding experience of electric motorcycles, making them feel more stable, lightweight, and comfortable during straight paths and when braking (Patil et al., 2021)

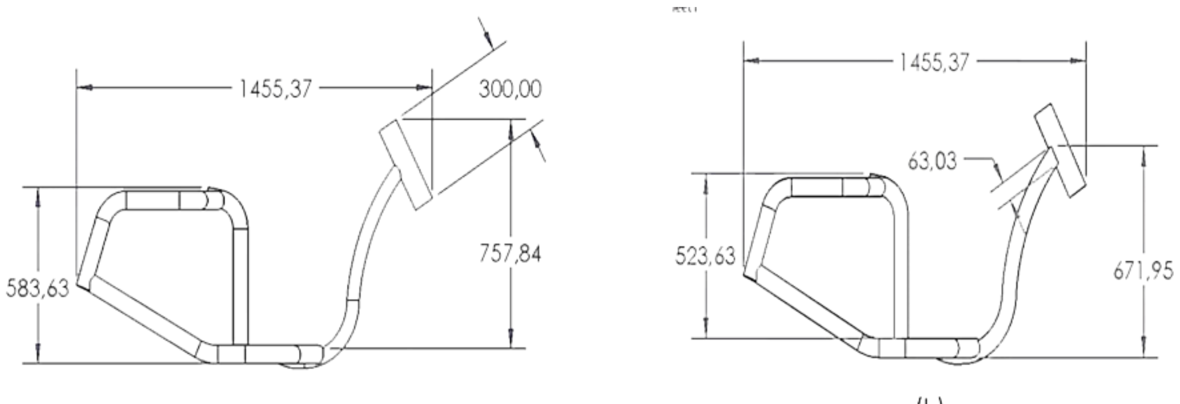
The aim of this study is to conduct a captivating and insightful comparison between two types of electric motorcycle frames: those constructed with Circular Tube and Square Tube profiles, utilizing AISI 1035 Steel (SS) and AISI 1020 as the base materials. The research endeavors to make a meaningful contribution to the advancement of electric motorcycles, with a specific focus on enhancing efficiency, reliability, and structural performance of the frame.

2. Methods

This research was carried out using the finite element analysis method using Solidworks 2021-2022 Research Licence software. Two frame models were constructed using circular and square tube profiles and different material types, namely AISI 1035 and AISI 1020. Both models were loaded with 490 N according to the actual use of the motorcycle frame. The mechanical properties of AISI 1035 and AISI 1020 materials are shown in Table 1. The design of the electric motorcycle frame is shown in Figure 1.

Table 1. Mechanical properties of AISI 1035 Steel dan AISI 1020

Property	AISI 1035 Steel	AISI 1020
Elastic Modulus	204999.9984 N/mm^2	200000 N/mm^2
Poisson's Ratio	0.29 N/A	0.29 N/A
Shear Modulus	79999.99987 Nmm^2	77000 N/mm^2
Tensile Strength	585.0000029 N/mm^2	420.507 N/mm^2
Yield Strength	282.685049 N/mm^2	351.751 N/mm^2
Thermal Expansion Coefficient	1.1e-05 /K	1.5e-05 /K
Mass Density	7849.999987 kg/m^3	7900 kg/m^3
Hardening Factor	0.85 N/A	- N/A
Thermal Conductivity	52 W/(m·K)	47 W/(m·K)
Specific Heat	486 J/(kg·K)	420 J/(kg·K)



(a) (b)

Figure 1. Design of an electric motorcycle frame: (a) Circular tube and (b) Square tube

3. Results and discussion

3.1 Von mises stress

The results of stress analysis that occurred in the frame when subjected to loading are shown in Figure 2. The frame utilizes circular tube profiles with AISI 1035 material (Figure 2.a), resulting in a maximum stress of 37.364 MPa, while in the circular tube frame with AISI 1020 material, the maximum stress observed is 33.533 MPa (Figure 2.b). In the electric motorcycle frame that employs square tube material with AISI 1035 (Figure 2.c), the maximum stress recorded is 54.724 MPa. Meanwhile, in the square tube frame with AISI 1020 material, the maximum stress observed is 54.734 MPa (Figure 2.d).

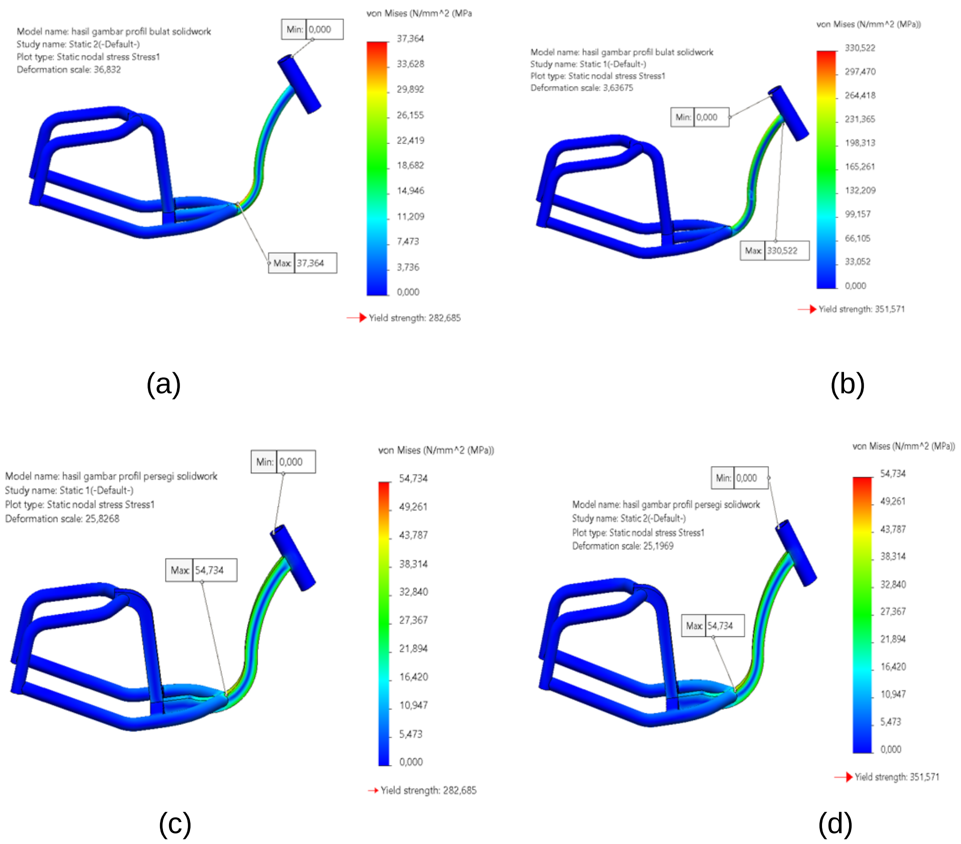
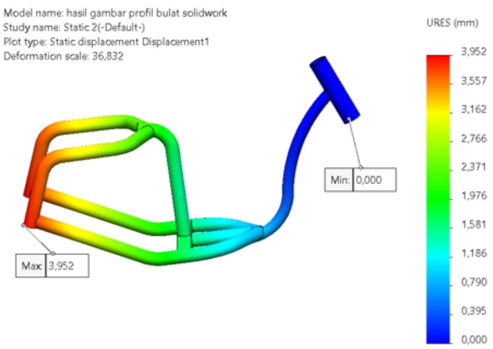


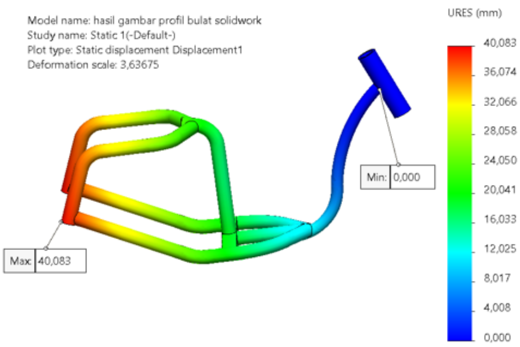
Figure 2 . Von mises stress

3.2 Displacement

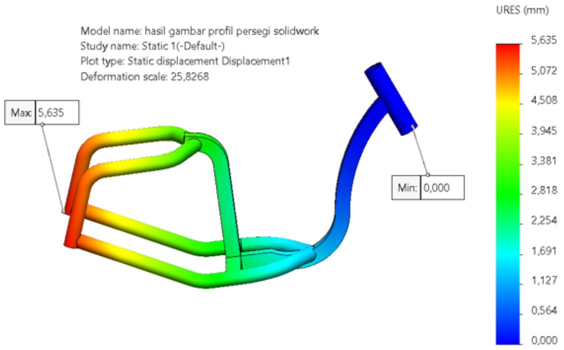
In the electric motorcycle frame using circular tube profile and AISI 1035 material type, the maximum displacement that occurs is 3.952 mm (figure 3.a), while in the frame with circular tube profile and AISI 1020 material type, the maximum displacement that occurs is 4.083 mm (figure 3.b). In the electric motorcycle frame using square tube material profile with AISI 1035 material type, the maximum displacement that occurs is 5.635 mm (figure 3.c), and with AISI 1020 material type, the maximum displacement that occurs is 5.776 mm (figure 3.d).



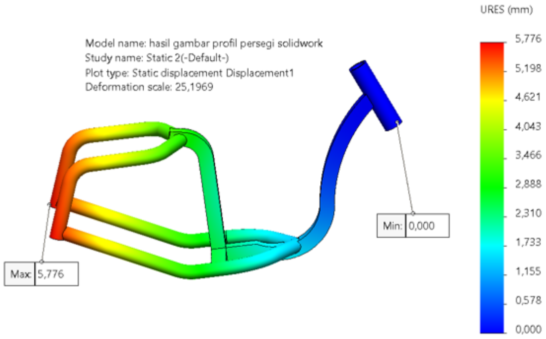
(a)



(b)



(c)



(d)

Figure 3. Displacement

3.3 Factor of safety

On an electric motorbike frame using a circular tube profile with material AISI 1035, the minimum safety factor value is 7.566 (Figure 4.a) and on an electric motorbike frame using material AISI 1020, the minimum safety factor value is 1.064 (Figure 4.b). On the other hand, in the frame of an electric motorbike using a square tube with material type AISI 1035, the minimum value of the safety factor is 5.165 (Figure 4.c). In the AISI 1020 type material, the minimum value of the safety factor is 6.423. The simulation results show that the largest minimum factor of safety value is in the electric motorcycle frame that uses a circular tube profile with material type AISI 1035. This shows that this design is the best.

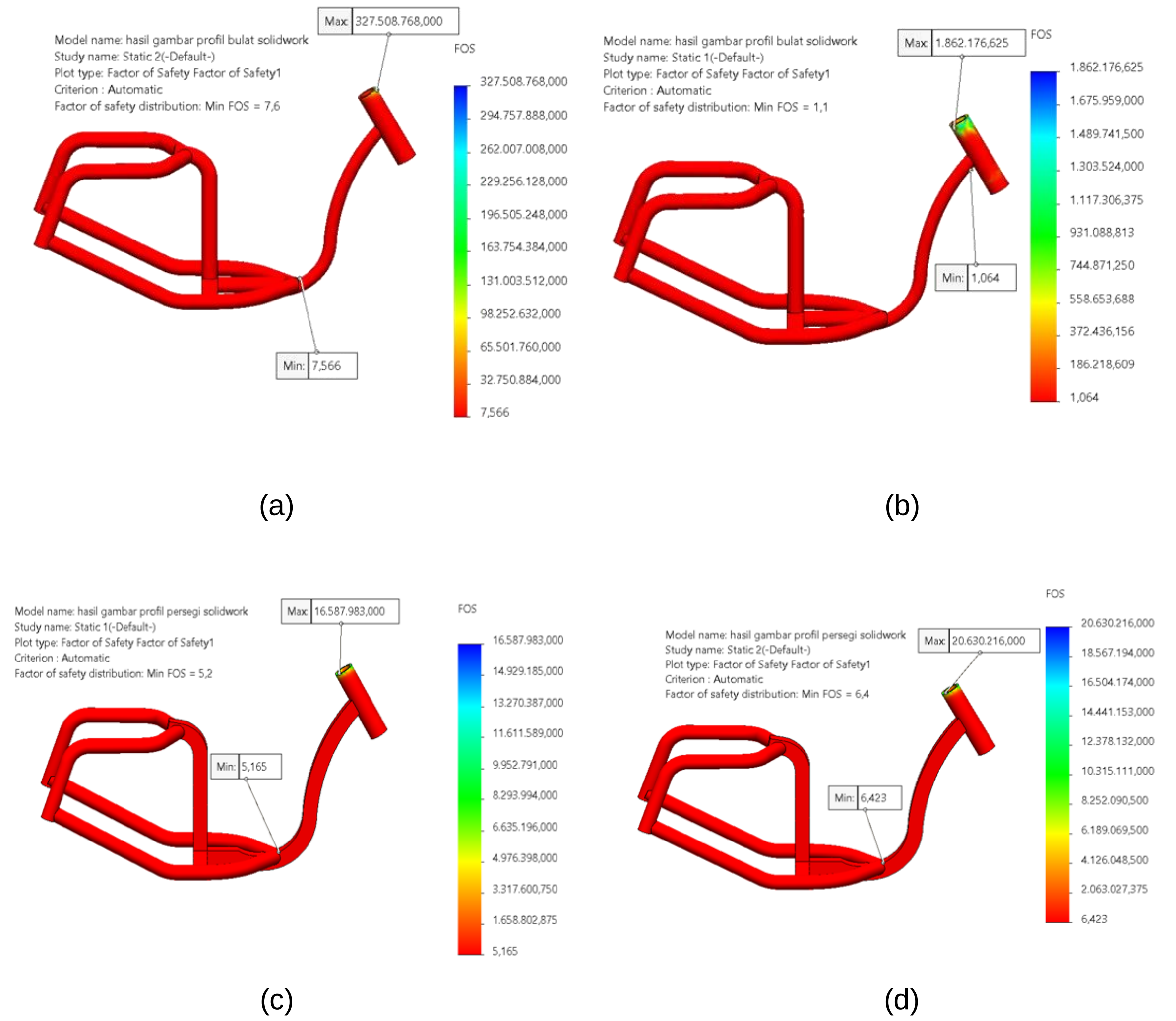


Figure 6. Factor of safety

4. Conclusion

The type of profile and material used significantly influence the quality of electric motorcycle frames. This study employed simulation methods with two different types of material profiles. Each frame with a distinct profile was constructed using two different materials as well. The research findings indicate that electric motorcycle frames made from AISI 1035 Steel with a Circular tube profile exhibit superior quality compared to frames using material 1020. Additionally, frames made from AISI 1035 Steel with a Square tube profile also outperform as a material choice for electric motorcycle frame fabrication. Therefore, it can be concluded that utilizing AISI 1035 material is more efficient in the production of electric motorcycle frames compared to AISI 1020 material.

Acknowledgements

The researcher expresses gratitude to the research team at the Manufacturing Laboratory of the Department of Mechanical Engineering, Faculty of Engineering, Universitas Negeri Padang, for their invaluable assistance in analyzing the design, providing advice, and granting access to facilities for conducting the FAE simulation.

Declarations

Author contribution

Nicolus Obeth Theopilus Simanjuntak plays a crucial role in this research by undertaking tasks such as designing the research concept, creating heatshik designs, conducting simulations, analyzing data, processing data, and writing articles. Meanwhile, Zeyar Min Thwin Htoo and Mukesh Singh are responsible for analyzing the data from the simulations, conducting discussions, and summarizing the research findings.

Funding statement

This research is an independent study and was not funded by any individual, organization, or company.

Conflict of interest

The authors declare no conflict of interest.

Ethical Clerance

There are no human subjects in this manuscript and informed consent is not applicable.

References

Amrullah, U. S., Perkasa, R. E., & Fakhruddin, M. (2023). Prototype Design of E-BMX 2000 Watt Electric Motorcycle. *Logic : Jurnal Rancang Bangun Dan Teknologi*, *23*(1), 55–61. https://doi.org/10.31940/LOGIC.V23I1.55-61

Baboria, M., & Gupta, S. (2023). Modelling and Structural Analysis of Hybrid Electric Vehicle using Solid Works and ANSYS. *Iconic Research And Engineering Journals*, *6*(7), 345–352.

Bahulekar, P., & Shinde, M. (2021). Design and Analysis of Connecting Rod of Less Effort Bicycle. *International Research Journal of Engineering and Technology*, *8*(4), 1835–1839. www.irjet.net

Johny, S., Kakkattil, S. S., Sunny, S., Sandeep, K. S., & Sankar, V. (2021). Design and fabrication of foldable electric bicycle. *Materials Today: Proceedings*, *46*, 9646–9651. https://doi.org/10.1016/J.MATPR.2020.07.157

Kondusamy, V., Ashik, M. J., & Raja, K. T. (2021). Design And Analysis Of Chainless Transmission Electric Bicycle. *Turkish Journal of Computer and Mathematics Education (TURCOMAT)*, *12*(10), 5848–5862. https://doi.org/10.17762/TURCOMAT.V12I10.5403

Kurhade, S., Kulkarni, S., Uplap, Y., Bhat, P., & Ugale, A. (2021). Design and Analysis of Hybrid E-bike chassis. *International Research Journal of Engineering and Technology*, *8*(5), 664–672.

Mutyala, S. (2019). Design and development of electric motorbike. *International Research Journal of Engineering and Technology*, *6*(12), 19–29.

Patil, S., Diwate, A. D., & Patil, A. S. (2021). Design and Development of Mountable Electrical Conversion Kit for a Motorcycle. *International Journal of Research Publication and Reviews*, *2*(8), 257–260.