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HOW TO UTILIZE AUTODESK FUSION 360 THAT REINFORCES PRODUCT REDESIGN SIMULATION?

Tri Andi Setiawan[1], Anda Iviana Juniani[1*], Dhika Adhitya Purnomo[1], Noorman Rinanto[2], Habib Ngumar Faruq[1]
*E-mail korespondensi: andaiviana@ppns.ac.id
[1]Engineering Design and Manufacture Study Program, Department of Mechanical Engineering
Politeknik Perkapalan Negeri Surabaya, Indonesia

[2]Electrical and Electronic Engineering Department
Nasional University of science and Technology, Taipe, Taiwan

ABSTRAK

Dalam industri desain saat ini, konsep desain generatif untuk perancangan dan pengembangan produk semakin berkembang. Ketika sebuah produk telah berada di pasar dalam jangka waktu yang lama, kebutuhan redesain produk menjadi hal yang tak terelakkan. Konsep redesain produk memodifikasi produk yang sudah ada untuk meningkatkan fungsionalitas, kegunaan, atau efisiensi manufaktur. Ini melibatkan perubahan desain produk, material, dan aspek lain untuk mencapai tujuan dan menyelesaikan masalah tertentu. Komunikasi antara desainer dan insinyur saat proses redesain produk muncul melalui perbedaan perangkat lunak. Kesulitan juga terletak pada komunikasi pemikiran desain dan strategi pemesinan. Autodesk Fusion 360 adalah perangkat lunak CAD/CAM dan CAE yang komprehensif. Penelitian ini bertujuan untuk menggunakan Fusion 360 untuk memperkuat simulasi desain ulang produk. Desain ulang produk yang lengkap mencakup beberapa bidang penting, termasuk desain industri, desain mekanik, rendering dan animasi, emulasi dengan dibantu komputer (CAE), dan manufaktur yang terintegrasi (CAM). Fusion 360 menyajikan ikhtisar kolaborasi, mendobrak batasan antara seni dan manufaktur, serta mengkritisi konsep desain dan proses manufaktur. Dengan menggunakan perangkat Fusion 360 untuk simulasi, analisis FEA statis dapat divisualisasikan. Untuk studi kasus, diamati bahwa hasil kekuatan, tegangan berada dalam nilai kekuatan luluh kritis dari masing-masing bahan, dengan kustomisasi massal dalam analisis struktur. Sebagai hasil dari analisis struktural selama tahap desain, penilaian sepeda motor kargo roda tiga dalam hal daya tahan dan ketahanan mekanisnya dapat dilakukan tanpa membahayakan pengguna.

Kata kunci: fusion 360, FEA simulation, optimization, product redesign, structural analysis

ABSTRACT

In today's design industries, the concept of generative design for product development is progressively evolving. When a product has been on the market for an extended period of time, redesigning becomes inevitable. Product redesign refers to modify an existing product to improve functionality, usability, or manufacturing efficiency. It involves changing the product's design, materials, and other aspects to address specific goals and problems. The communication between designers and engineers used to go on through different software products, tool commands, and even industry terms. However, the difficulty also lies in communicating design thoughts and machining strategies. Autodesk Fusion 360 is a comprehensive CAD/CAM and CAE software tool. This article proposes to utilize Fusion 360 for reinforcing product redesign simulation. A complete product redesign covers several significant areas, including industrial design, mechanical design, rendering and animation, computer-aided emulation (CAE), and computer-aided manufacturing (CAM). Fusion 360 presents an overview of collaboration, breaks the barriers between art and manufacturing, and blocks between design and processing. Using Fusion 360 user interface for simulation, the static FEA simulation results can be visualized. For the case study, it is observed that the results for stress and global displacement are within the critical yield strength values of the respective material, with mass customization. As a result of structural analysis during the design stage, the assessment of three-wheeled cargo motorcycle in terms of their durability and mechanical resistance is possible without putting the user at risk. Based on the obtained results, the structure strength was compared.

Keywords: *Fusion 360, FEA simulation, optimization, product redesign, structural analysis*

INTRODUCTION

In product development, including product design improvements, it is emphasized that everything is considered at the initial design stage because it significantly affects the later stages of product development and throughout the product life cycle (Juniani et al., 2022).

The relationship between Fusion 360 simulation and optimization in product development is intertwined and complementary. Fusion 360 offers simulation and optimization tools that work together to improve the design and performance of products. Simulation in Fusion 360 involves creating virtual prototypes and subjecting them to various tests and analyses to evaluate their behavior under different conditions. This includes structural analysis, thermal analysis, fluid flow analysis, and more. Simulation helps identify potential design flaws, optimize performance, and ensure that the product meets desired specifications and requirements.

Structural analysis helps assess the performance and reliability of the redesigned product. It allows engineers to analyze how the product will behave under different loads, stresses, and environmental conditions (Rahman et al., 2020; Setiawan et al., 2023). By simulating and analyzing the structural integrity, engineers can identify weak points, potential failure modes, and optimize the design to ensure it meets safety and performance requirements. Structural analysis plays a crucial role in product redesign by providing valuable insights into the performance, reliability, and optimization of the redesigned product (Jumandono & Juniani, 2017; Prabowo et al., 2018). It helps engineers make informed decisions, optimize materials and designs, reduce costs, ensure compliance, and ultimately deliver high-quality products to the market.

This article's writing structure is divided into four sections. The second section presents a literature review of research materials and describes the research methodology in depth. The third section presents the results and the discussion. The study's findings are then summarized in the final section.

MATERIALS AND METHOD

This section will discuss the primary literature review supporting this article, as well as the research methods.

Product Redesign

Existing products are frequently redesigned to create new products. Product redesign has become an evolutionary strategy in product development (Juniani et al, 2022; Zhang et al., 2019). The primary objective of product redesign is to increase customer contentment by enhancing selected target features. Consequently, identifying product features that will be improved is an essential aspect of product redesign research. These enhanced product features are implemented through product redesign to increase customer satisfaction and adapt to changing customer requirements. In recent years, identifying product features that should be enhanced or redesigned has become an essential area of study to increase product quality and decrease manufacturing costs.

Autodesk Fusion 360

Autodesk Fusion 360 is an all-encompassing 3D computer-aided design (CAD), computer-aided engineering (CAE), and computer-aided manufacturing (CAM) application. It is frequently used for product development and prototyping by engineers, designers, and manufacturers (Rahman et al., 2020; Sholeh et al., 2018). Fusion 360 provides various practical tools and capabilities that facilitate product redesign. Included are:

a. Fusion 360 enables the creation of parametric 3D models. This model indicates that the design is readily modifiable by adjusting dimensions, angles, and features. Modifications can be made swiftly and efficiently, allowing for an efficient product redesign.
b. Collaboration and Version Control. Fusion 360 provides cloud-based tools enabling multiple team members to collaborate on a project simultaneously. Additionally, it includes version control capabilities, enabling users to monitor and manage design iterations. This facilitates collaboration and streamlines the product redesign, particularly in a team setting.
c. Simulation and Analysis. Fusion 360 incorporates robust simulation and analysis tools that allow engineers to assess the redesigned product's performance, structural integrity, and behaviour. It can simulate various conditions and forces, allowing for the identification of potential flaws or areas for enhancement prior to production.
d. Fusion 360 provides realistic rendering and visualization capabilities, enabling designers to generate high-quality visual representations of the redesigned product. This helps stakeholders and clients better comprehend the proposed changes and make informed decisions regarding the redesign.
e. Manufacturing and CAM Integration: Fusion 360 supports computer-aided manufacturing (CAM) capabilities, allowing for a smooth transition from design to production. It contains tools for generating toolpaths,

simulating machining operations, and producing machine code for CNC (Computer Numerical Control) machinery. This integration ensures that the redesigned product can be efficiently produced.

Overall, Autodesk Fusion 360 offers a robust set of tools and features to facilitate the product redesign process. It streamlines the entire design-to-manufacturing workflow, enabling designers and engineers to create, modify, simulate, and visualize their redesigned products efficiently.

Research Method

The research article starts with performing a literature review, including a gap to study the topic in question. This article's objectives were created after research problem defined. Then, the designing and modeling of three-wheeled cargo motorcycle were performed by utilizing Fusion 360 for design optimization. First, the product redesign is modeled using computer-aided design to create a 3D model. Moreover, Finite Element Method (FEM) simulation requires a mesh generation to numerically model the three-wheeled cargo motorcycle after the data are selected and inputted to the solver. At the next stage, the loading and boundary conditions are needed to be defined before the FEM is performed. The obtained results are verified to ensure the generated results from the FEM method. The overall research flowchart is portrayed in Figure 1.

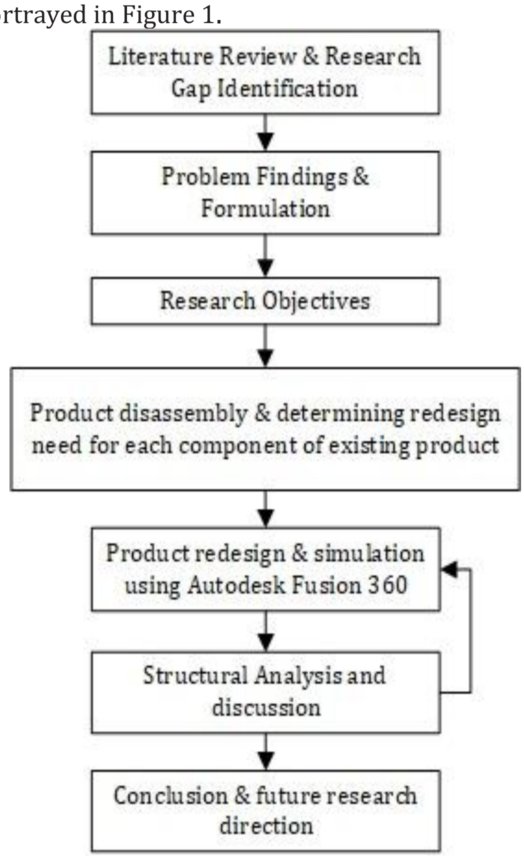

Figure 1. Research Method

RESULT AND DISCUSSION

Fusion 360 allows for the import of geometric models created by CAD to perform finite element analysis on static structures, dynamic features, etc. DFR analysis will be performed by structural analysis via Fusion 360. The driven optimization feature can generate analysis and optimization for deterministic designs. A typical analysis feature is the model's size, such as volume, moment of inertia, clearance, etc. Product design exploration will provide performance analysis for design optimization based on the results of the analysis of several parts of the design to find design variable values.

Analysis of Existing Product Design

The vehicle is one of the means of transportation humans use to meet their needs. As a means of transportation, vehicles must provide safety and comfort for motorists. The development of technology and science, along with the increasing human need for means of transportation, has made people more selective in choosing vehicles according to their needs. The development of the automotive world has been very rapid lately, and manufacturers are continuously trying to improve the quality of their products to meet consumer desires and compete in the market (Juniani et al., 2021). Today, many three-wheeled motorcycles are developing by adding an open bed at the rear.

The three-wheeled cargo motorcycle (see Figure 2) shows that motorcycles as public vehicles have more functions as a means of transportation. Design engineering on motorbikes such as three-wheeled cargo motorcycle has the effect that the stability of these vehicles is different from motorbikes in general. Therefore, structural analysis in redesigned products is essential to ensure product strength, stability and reliability.

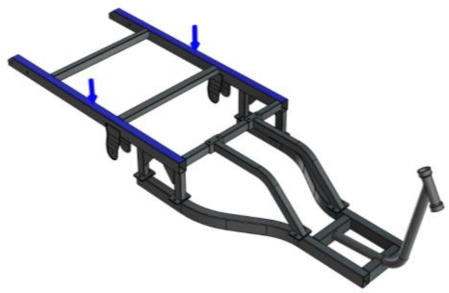

Figure 2. Existing design of three-wheeled cargo motorcycle with load

The material used in Figure 2 is steel-standard structural with the following specifications; the density is 7.8E-06 kg/ mm3, yield strength is 248.2 MPa, Ultimate Tensile Strentgth is 475.7 MPa, Young's Modulus is 200 Gpa and the Poisson's Ratio is 0.26. The loading position is given to the entire surface of the body frame, with a load of 509.8 kg, which is assumed to be the maximum load that a three-wheeled cargo motorcycle can generally accept. The loading position and size can be seen in Figure 2. The support is given to the steering wheel and the two shock breaker brackets with a patented fixed type on the X, Y, and Z axes, which means that the three-wheeled cargo motorcycle frame cannot move towards the X, Y, and Z axes. Moreover, the type of pedestal can be seen in Figure 3.

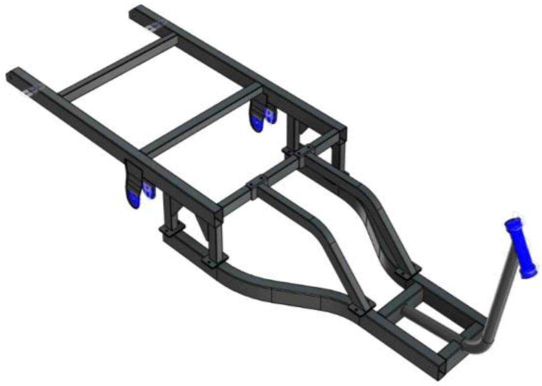

Figure 3. Existing design of three-wheeled cargo motorcycle with constraints' focus

The loading Position in Figure 2 is given to all faces on the body frame; the load given is 509.8 kg, likened to the maximum load tricycle can generally accept. The loading position and size can be seen in Figure 3. The support is given to the steering wheel and the two shock breaker brackets with a fixed type which means they are patent with the X, Y, and Z axes, which means that the three-wheeled motorcycle frame cannot move towards the X, Y, and Z axes. The position and type of support can be seen in the Figure 5.

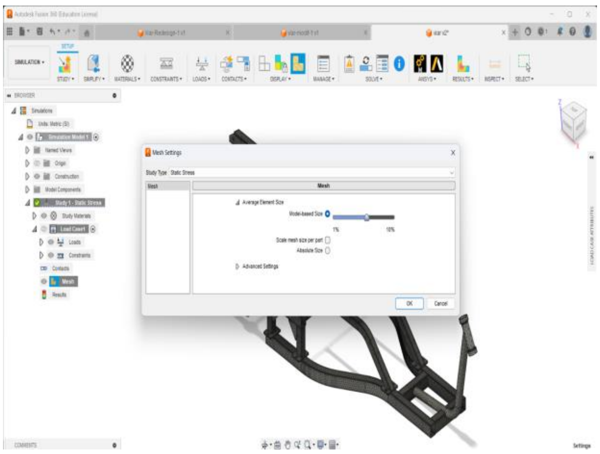

Figure 4. Mesh specifications

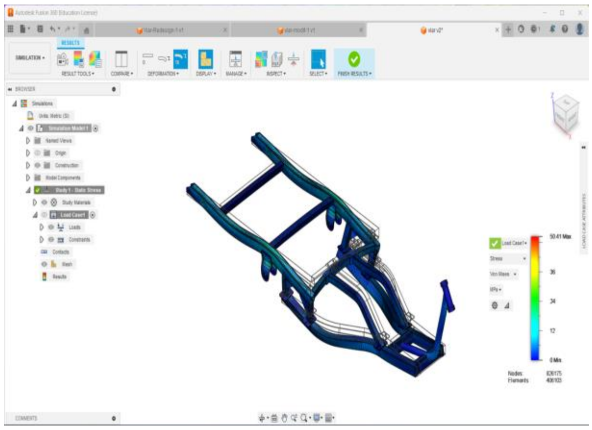

Figure 5. Stress testing

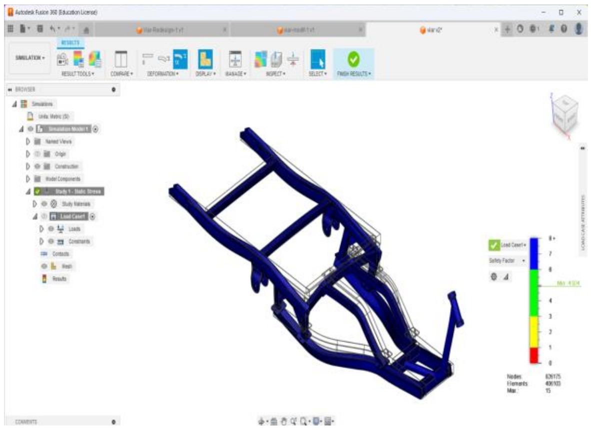

Figure 6. Safety Factor

The mesh used is Model-based Size with a size of 5% to make it easier for the user to conduct the analysis process (see Figure 4). The analysis results in Figure 6 obtained a 4.9 in safety factor, with the critical point between the body frame and the front frame and a maximum stress of 50.4 MPa in the body frame area. Stress analysis is allowed using the following equation:

$$\sigma_{ijin} = \frac{\sigma y}{(Sf.k)}$$

$$\sigma_{ijin} = \frac{248{,}2}{(1{,}25.1)} = 198{,}5 \text{ MPa}$$

with:

σ_{ijin} = Tegangan ijin (Mpa)
σy = Yield Strength (250 Mpa)
Sf = Safety Factor (1.25)
K = Faktor koreksi material (1)

So the stress value from the analysis using the software is said to be failed or unsafe if the stress value exceeds 198,5 MPa. The stress for the existing product is safe because it has a value of 50,4 MPa, which is less than the allowable stress testing.

Utilizing Fusion 360 in Product Redesign Simulation

Determining the geometric model is the first step in product redesign testing. A geometric representation method designed using a 2D or 3D approach. In this test, this research used a 3D approach. Since the body frame structure in the existing product geometry model had design flaws, removing the body's bottom frame and altering the front frame's profile dimensions were the results of this test (see Figure 7).

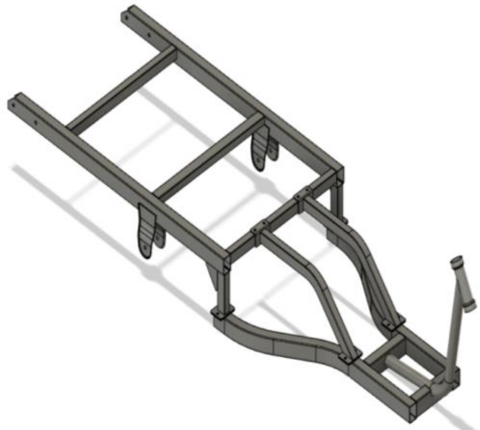

Figure 7. Redesign of three-wheeled cargo motorcycle

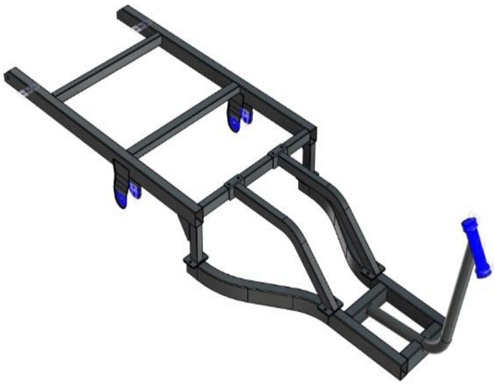

Figure 8. Boundary Condition

The geometry model will be divided into finite elements in the meshing process. Excellent meshing is very important because it can affect the accuracy and efficiency of the analysis. In the load and boundary stage, determining the boundary conditions and describing the restrictions or requirements applied to the boundary points of the structure are to be analyzed. Select and identify the relevant boundary points in the structural model. Once the boundary conditions have been determined, the values and parameters of the boundary conditions must be determined. Fixed restrictions are restrictions on translational, rotational, or both movements. In this analysis, the limitations can still be seen in Figure 8 and Figure 9. All fixed limitations for type of U_x, U_y, and U_z.

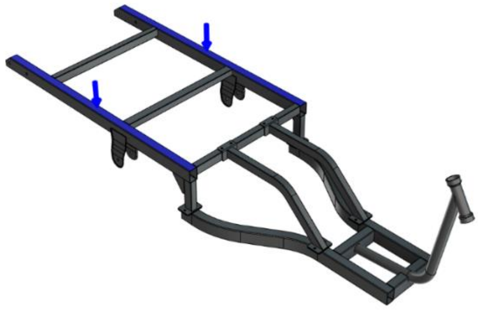

Figure 9. Load Force of product redesign

Table 1. Mesh Refinement

Average Element Size (% of model size)	
Solids	6
Scale Mesh Size Per Part	No
Average Element Size (absolute value)	-
Element Order	Parabolic
Create Curved Mesh Elements	Yes
Max. Turn Angle on Curves (Deg.)	60
Max. Adjacent Mesh Size Ratio	1.5
Max. Aspect Ratio	10
Minimum Element Size (% of average size)	20
Number of Refinement Steps	0
Results Convergence Tolerance (%)	20
Portion of Elements to Refine (%)	10
Results for Baseline Accuracy	Von Mises Stress

In this analysis, selecting suitable material is crucial for accurate and relevant results. The selection of this material involves considering the characteristics of the material that are relevant to the analysis and then inputting the material data. The materials and data used in this analysis can be seen in the Table 2.

Table 2. Material Datasheet

Density	7.8E-06 kg / mm^3
Young's Modulus	200000 MPa
Poisson's Ratio	0.26
Yield Strength	248.2 MPa
Ultimate Tensile Strength	475.7 MPa
Thermal Conductivity	0.045 W / (mm K)
Thermal Expansion Coefficient	1.17E-05 / K
Specific Heat	480 J / (kg K)

The analysis results are obtained in the form of structural response which includes safety factor, stress, deformation, and displacement. Following are the results of the analysis of the three-wheeled cargo motorcycle frame structure.

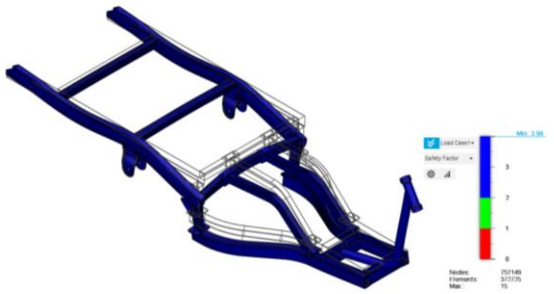

Figure 10. Safety Factor

The analysis results are obtained through structural response, including safety factors, stress, deformation, and displacement. A safety factor is a concept used to evaluate the safety and reliability of a structure. The safety factor describes the ratio between the strength or capacity of a structure with the applied load. The analysis results obtained a safety factor 3.99 with a critical point in the engine frame area (Figure 10).

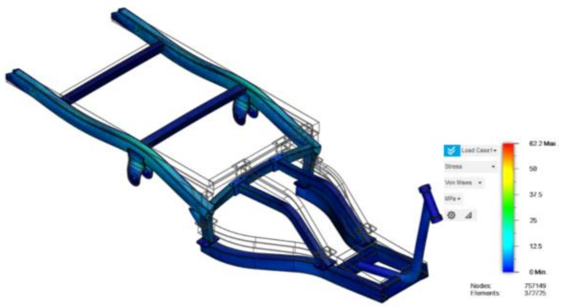

Figure 11. Maximum Stress

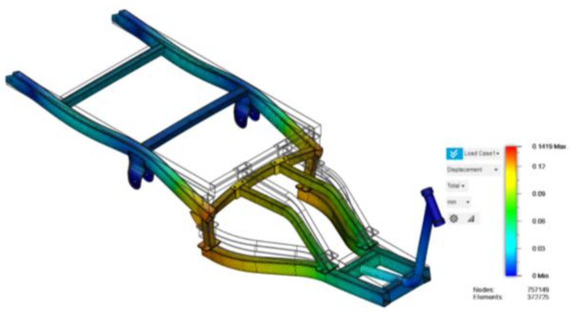

Figure 12. Total Displacement

The maximum stress is identified to understand the level of strength and risk of failure of a structure. The visualization of the analysis results shows that the areas in the structure experiencing the maximum stress (Figure 11) are marked in red or yellow. If the maximum stress exceeds the strength limit of the structural material, then there is a risk of failure of the structure. The analysis obtained a maximum stress of 62.2 MPa with a critical point in the body frame area.

Total displacement refers to the change in position or overall deformation of a structure under load. Information about the total displacement is vital in evaluating a structure's stability, durability, and performance. Excessive or poorly distributed total displacements may indicate a problem in the structural design. The analysis results obtained a total displacement of 0.1419 mm, with a critical point between the body and front frames as seen in Figure 12.

CONCLUSION

This research utilizes Autodesk Fusion 360 to strengthen product design simulations. The argument for using Autodesk Fusion 360 for CAD/CAM modelling is that this tool can combine engineering and analysis tools on a single platform, increasing efficiency and simplicity in collaborative product design development. CAE studies were performed on the bracket using Autodesk Fusion 360 to simulate its performance under realistic loading conditions and constraints, enabling the determination of stresses, displacements, and safety factors. Autodesk Inventor is extremely useful for product design, tooling, mechanical design, and simulation.

Using the 3D design model of the frame of a three-wheeled cargo motorcycle, a size optimization design was performed to enhance frame strength, and the following results were obtained. The loading and boundary conditions for the frame of a three-wheeled cargo motorcycle took into account the weight of the driver and cargo, as well as the motion conditions that may occur during straight-driving and curve-driving. Structural analysis during the design stage results the assessment of three-wheeled cargo motorcycle in terms of their durability and mechanical resistance is possible without putting the user at risk. Increasing the thickness of the bracket through size optimization had the greatest impact on enhancing the longitudinal bending and torsional strength of the frame of a high-load three-wheeled cargo motorcycle.

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