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NUMERICAL STRUCTURE ANALYSIS OF REAR DISC BRAKE CALIPER BRACKET MINI DIRT BIKE 50cc

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ABSTRACT

The numerical structure of the rear disc brake caliper bracket on a 50cc mini dirt bike will be studied. This study includes modeling bracket design using the finite element method. The analysis is focused on the distribution of tensions, strains, and deformations resulting from static loads. The selection of the material used is aluminum alloy 6061-T6 and cast carbon steel is often used because of its light and strong nature. In addition, finite element analysis (finite element method) helps in evaluating the strength, maximum voltage, as well as safety factors of the designed components. This research focuses on the optimal design of brake caliper brackets for applications on 50 cc mini dirt bikes. Two variations of design optimization were introduced through a weight optimization process to achieve a maximum mass reduction for 6061-T6 aluminum and Cost Carbon Steel of 10.38% and 10.8% of the initial weight, respectively. The results of the study with loading from 0 N to 300 N simultaneously showed the maximum value of Von Misses Stress for aluminum 6061-T6 and Cost Carbon Steel of 6.12x107 Pa and 8.34x107 Pa, respectively. Then the maximum strain values on aluminum 6061-T6 and Cost Carbon Steel are 0.020 mm and 0.00347 mm, respectively. Finally, the maximum safety factor values for 6061-T6 aluminum and Cost Carbon Steel are 3.55 and 8.04, respectively.

***Keywords**: structure analysis, brackets, disc brake calipers, dirt bikes, finite element methods.*

1. INTRODUCTION

The disc brake caliper bracket is one of the important components in the braking system, especially on 50cc mini dirt bikes that are often used for off-road terrain. These components must be designs with a strong structure and be able to withstand the loads and pressures generated during the braking process. Designs and analysis on motorcycle disc brake test equipment, which provides important insights into engineering approaches in ensuring the strength and stability of braking systems. Considering these principles, this study focuses on analyzing the numerical structure of the rear disc brake caliper bracket of a mini dirt bike to improve its efficiency and reliability (Andika et al., 2022).

In a vehicle's braking system, one of the important aspects to consider is the efficiency of brake cooling, especially on motorcycles that are often used on rough terrain such as dirt bikes. Previous study by redesigns the brake cooling duct of the front disc of a motorcycle using the Computational Fluid Dynamics (CFD) method. The study highlights that the optimization of the cooling duct designs can significantly reduce the temperature of the brake components, thereby improving the performance and service life of the brakes. This approach demonstrates the relevance of numerical technology in the analysis and development of automotive components, including for brake caliper brackets on mini dirt bikes.

Numerical structure analysis is one way to understand the influence of dynamic loads on the durability of materials and the stability of these components (Sofana et al., n.d.). Engineering analysis, finite element methods have been widely used to evaluate mechanical structures, including in designs and material modification applications. conducting research related to finite element analysis in running prostheses with a focus on the influence of material and designs changes on structural performance. The results of this study show that the use of numerical simulation methods can provide in-depth insights related to the mechanical characteristics of a component before the manufacturing process. With a similar principle, the structural analysis of the disc brake caliper bracket on a 50cc mini dirt bike can also be carried out to ensure the strength and reliability of the designs (Yama et al., 2024).

Various studies have been conducted to provide important insights into how the designs and selection of materials affect the performance and durability of braking systems, especially in overcoming the heat generated during braking. A similar approach can be applied to the development of disc brake caliper brackets, especially for mini dirt bikes, which often face dynamic loads and extreme conditions. Therefore, the study of the numerical structure of the bracket becomes relevant in ensuring its strength and stability during use (Soejatmiasih et al., 2022).

Finite *Element Analysis* (FEA) Method, it is known that numerical analysis-based approaches play an important role in improving the performance and reliability of a mechanical component. A similar principle can be applied in the development of bracket structures in disc brake systems. These components play a vital role in maintaining the stability and efficiency of the brake system through its load distribution and structural strength. By utilizing in-depth numerical analysis methods, this study will focus on evaluating the structure of the rear disc brake caliper bracket on a 50cc mini dirt bike to identify designs improvement opportunities that can improve the safety, comfort, and efficiency of its use (Elmiawan et al., 2022).

Figure 1. Traill motorcycle caliper bracket
(Source: https://images.app.goo.gl/NB6jCN2dBUxsi2ke7)

Vibration and sound characteristics are greatly influenced by mechanical designs factors, component materials, and the interaction between brake pads and discs. These results provide the view that the development of brake components should not only focus on vehicle stopping functionality, but also should consider acoustic and vibration aspects to improve user comfort. These findings are relevant in the analysis of the structure of disc brake caliper brackets on mini dirt bikes, especially in understanding the factors that can affect the performance and stability of the braking system (Rusli et al., 2010).

In the process of designs mechanical components, such as the disc brake caliper bracket on a 50cc mini dirt bike, material selection is one of the important steps to ensure the performance and reliability of the system. In his book Materials (Ashby et al., n.d.) *Selection in Mechanical Designs*, he explains that the material selection process not only considers mechanical properties, but also economic, environmental, and aesthetic factors. Therefore, understanding the characteristics of materials, such as strength, stiffness, and resistance to corrosion and fatigue, is essential to ensure that components are able to function properly under a wide range of operational conditions. This approach is the basis for evaluating the numerical structure of the disc brake caliper bracket to fit the specific needs of a 50cc mini dirt bike.

A systematic approach to numerical structure analysis is essential to support energy and resource efficiency in manufacturing processes. It is proposed that a process- and system-based approach can provide important insights in reducing energy consumption and raw material use. This perspective is relevant for the development of rear disc brake caliper brackets on 50cc mini dirt bikes, where the efficient designs not only optimizes performance, but also minimizes environmental impact during the manufacturing process. By understanding the structural and material aspects, this approach allows for a balance between mechanical strength and production efficiency (Duflou et al., 2012).

The data augmentation approach is one of the important steps in data processing, especially in the development of deep learning models. According to time series-based data augmentation, it can improve model performance by generating relevant data variations without losing its original characteristics. In the context of testing the numerical structure of disc brake caliper brackets, this data augmentation method has the potential to support a more accurate analysis of the material's response to various loading conditions. By expanding the scope of the data used, the numerical simulation results can better reflect real-world conditions, thus supporting the development of more reliable designs (Wen et al., 2020).

The numerical analysis approach is one of the methods that is often used in evaluating the performance of mechanical structures. Based on research that emphasizes the importance of simple, valid, and reliable measuring instruments, this approach is also relevant to be applied in engineering designs studies, including in disc brake caliper brackets. Their research provides a methodological foundation for developing evaluation tools that are not only efficient but also accurate in measurement (Miller & Duncan, 2003).

The validation of the finite element (FEM) method in engineering research has been proven by various studies, including a study conducted by Rusli, Meifal Bur, Mulyadi Hidayat, and Harri, which analyzed residual stress and distortion in the stiffener plate structure with variations in the welding sequence. The results of the study show that the FEM simulation is able to provide high accuracy and close to the experimental results. Therefore, the application of the FEM method in the analysis of the brake caliper bracket structure of the rear disc of a 50cc mini dirt bike is a strategic step to ensure the accuracy of the designs. In addition, FEM-based simulations can help understand load distribution patterns as well as identify critical points that may occur in components, especially when facing dynamic loads during the braking process. This approach is expected to result in a designs that is not only reliable, but also efficient in the use of materials (Wibowo et al., 2016).

From the various references above, the research to be conducted focuses on an in-depth understanding of the material's response to the forces acting on caliper brackets under extreme conditions that are susceptible to damage if not properly designs. This study uses SolidWorks 2024 software with a 9020008745512730KKW9WVB6 license for simulation and analysis work on rear disc brake caliper brackets. Mechanical forces such as tension, strain, displacement and factor of safety will be the output priorities of this caliper bracket simulation research. The novelty in this study compared to previous research is the topology of the caliper bracket designs, the dynamic loading used, and the selection of Aluminum 6061T6 and Cast Carbon Steel materials. This research is expected to be a reference for manufacturers in making caliper brackets by paying attention to the designs and materials used, so that economic value is achieved without reducing its mechanical strength.

2. METHOD

This research was conducted by reviewing relevant literature to identify the need and urgency in studying the topic of structural analysis and lightweight designs on the brake caliper bracket of the rear disc of a 50cc mini dirt bike. The study also helps to understand the latest technological developments in the designs and simulation of motorcycle components. Furthermore, the research process includes modeling caliper brackets by utilizing computer-based software (CAD) to produce a 3D model that meets the criteria of lightweight designs. Designs optimization is carried out through material analysis and geometric structure to ensure that the bracket is not only lightweight but also able to withstand the load when operating (S/o & Royani Munander, n.d.)

The methods used in this study include finite element simulation (FEM), which is the main element in the analysis of numerical structures. This process begins with the creation of a mesh that functions to model the bracket digitally. The data used includes material properties, model geometry, and loading. All of this data is then processed using a FEM solver to evaluate the voltage distribution and deformation in the bracket. These simulations are important to identify potential structural problems before they are implemented into real applications. This step supports the achievement of bracket efficiency and reliability on 50cc mini dirt bikes, as well as contributing to small vehicle technology innovation (Sopian et al., 2021).

The method of structural analysis on the brake caliper bracket of the rear disc of a 50cc mini dirt bike was carried out with a Finite Element Method (FEM) approach. This process refers to research that discusses the influence of axial loads on beams as a guide in identifying the behavior of materials under certain loads. In this study, a bracket model was created using CAD software and imported into the structure analysis software to simulate the distribution of tension and deformation due to the force exerted by the brake caliper during braking operation. The axial load applied is adapted by taking into account the operational dynamics of the mini dirt bike, as well as the nature of the bracket material according to technical specifications. The simulation results are analyzed to determine with an emphasis on the reliability of the structure under extreme conditions (Giovani & Mukhlis, 2019).

The outline of the research to be carried out is explained in the flowchart as shown in Figure. 2.

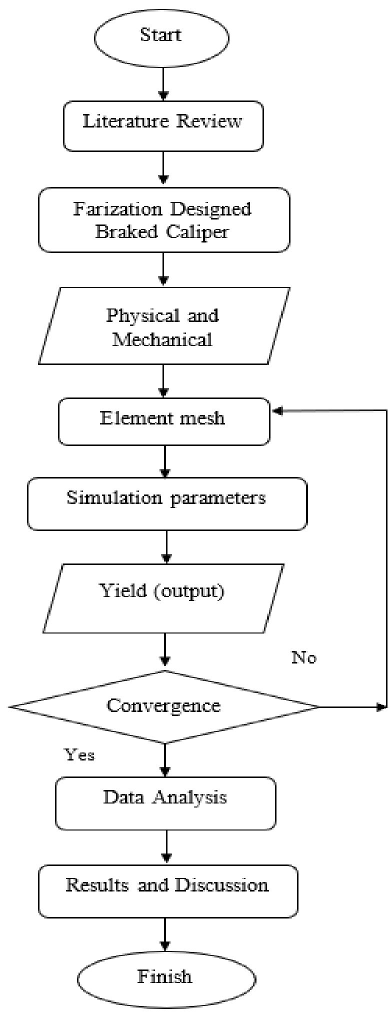


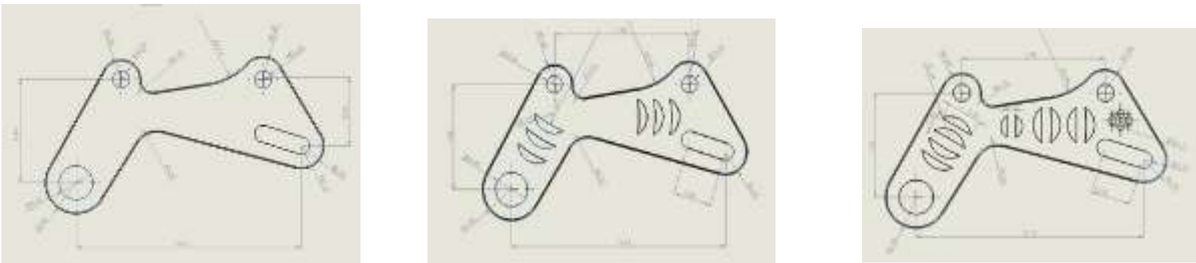
Figure 2. Research flowchart

3. RESULTS AND DISCUSSION

The proposed rear disc brake caliper bracket designs has dimensions of 75 mm in length, 40 mm in width, and 2,5 mm in thickness as shown in Figure 3. Once the caliper bracket designs is created, the next step is to create a designs topology. This topology aims to produce components that are strong enough but still lightweight and can support optimal braking system performance on 50cc mini dirt bikes. The designs topology is divided into 3 designs (Figures 4 & 5) with a priority on reducing the material and thickness of the bracket which is adjusted at several points to reduce the mass without reducing its structural strength. This mass reduction is carried out in the parts that are least loaded, such as in areas that are not directly connected to the calipers or fastening bolts.

In this numerical study, the materials used are Aluminium 6061T6 and Cast Carboon Steel. These two materials were chosen because they are easy to get on the market and to maintain the light weight of the caliper bracket of the 50cc mini dirt bike. The properties of Aluminum 6061-T6 and Cast Carboon Steel are shown in Table 1.

Figure 3. Caliper bracket designs



(a) (b) (c)

Figure 4. Caliper bracket designs
(a) Initial designs, **(b)** First optimization, **(c)** Second optimization

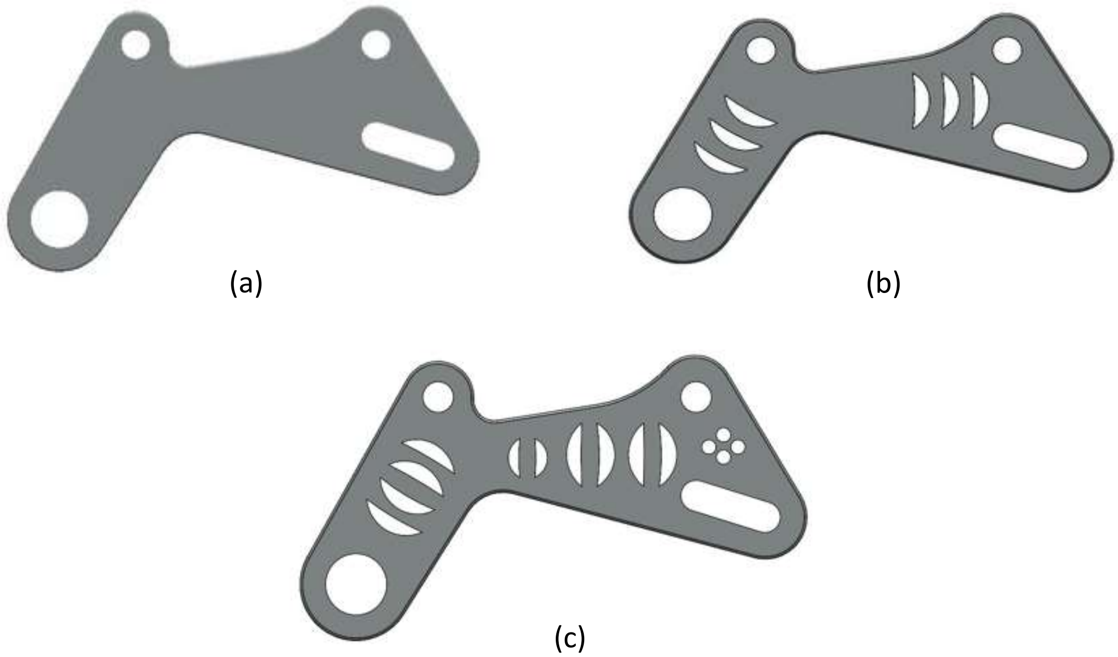
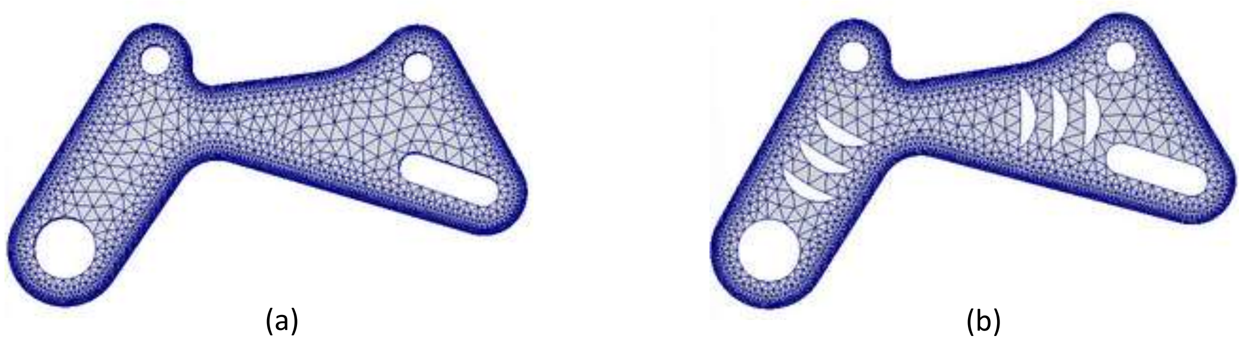


Figure 5. Proposed designs of rear brake caliper bracket
(a) Initial designs, **(b)** First optimization, **(c)** Second optimization

Table 1. Material Properties of Aluminium Alloy 6061 T6 (SS), (Al) and Structural Steel Cast Carboon Steel (St)

Property	Al	St
Density	2,700 kg/m³	7,800 kg/m³
Elastic Modulus	6,900 MPa	2,000 MPa
Rasio Poisson	0,33	0,32
Yield Strength	275 MPa	248 MPa



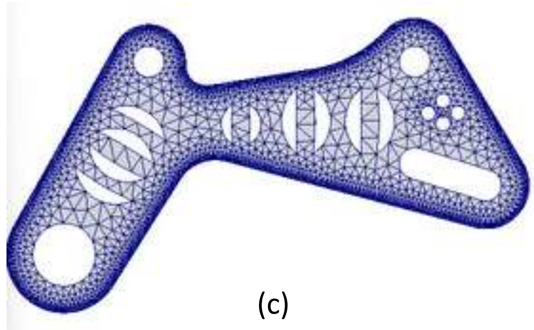


Figure 6. Mesh yield
(a) Initial designs, **(b)** First optimization, **(c)** Second optimization

Mixed curvesh based mesh Selected in the manufacture of the mesh for the rear disc brake caliper bracket model of the 50cc mini dirt bike. Figure 6 shows that the mesh element is a representation of the initial shape of the bracket. Figure A The size of the mesh element was determined to be 3,573 mm with the aim of providing precision to the analyzed structure. A smoothing process is being applied to ensure the smoothness of the resulting mesh so that the model is more accurate in distributing the tension. In this simulation, the mesh used is 58984 nodes and 34605 elements in total, which is considered representative enough to form a bracket model.

Figure B The size of the mesh element was determined to be 3,493 mm with the aim of providing precision to the analyzed structure. A smoothing process is being applied to ensure the smoothness of the resulting mesh so that the model is more accurate in distributing the tension. In this simulation, the mesh used is 59099 nodes and 34646 elements in total, which is considered representative enough to form a bracket model.

Figure C The size of the mesh element was determined to be 3,441 mm with the aim of providing precision to the analyzed structure. A smoothing process is being applied to ensure the smoothness of the resulting mesh so that the model is more accurate in distributing the tension. In this simulation, the mesh used is 60,100 nodes and 35,119 elements in total, which is considered representative enough to form a bracket model. The simulation considers the worst-case scenario of the loading condition. This simulation applies 30 steps of loading conditions with linear increments from 0 N to 300 N maximum force in the -X direction, referring to Figure 7. Therefore, a change in stress to strain or a change in displacement to a given rise in force can be observed.

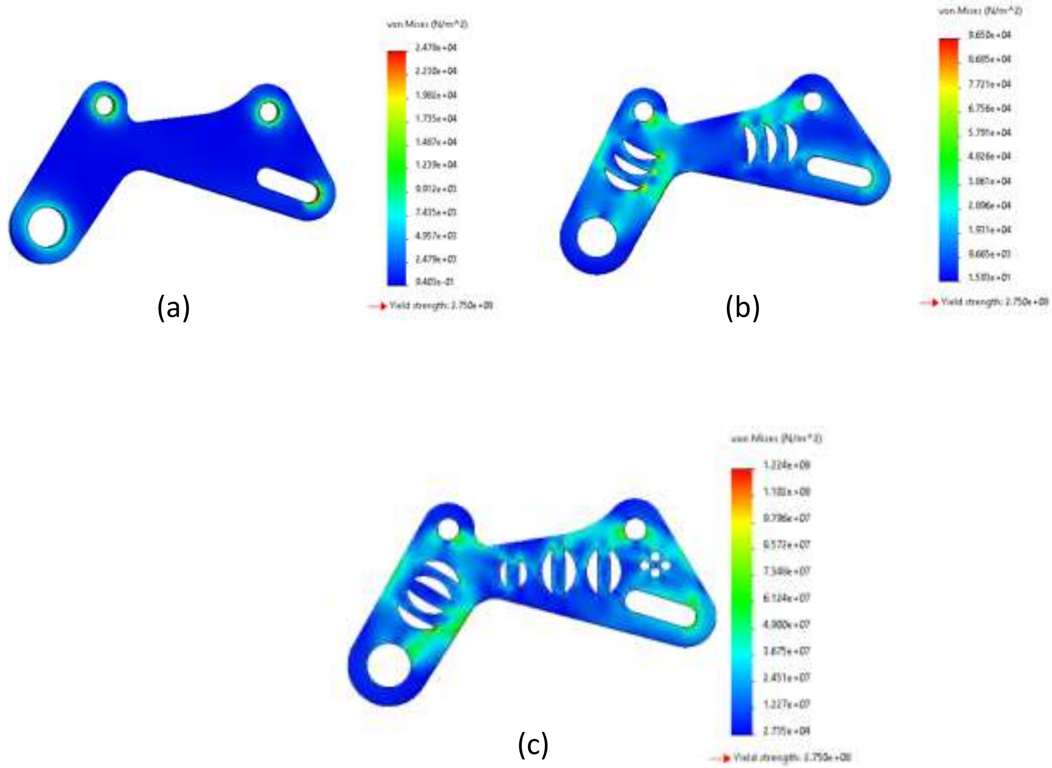
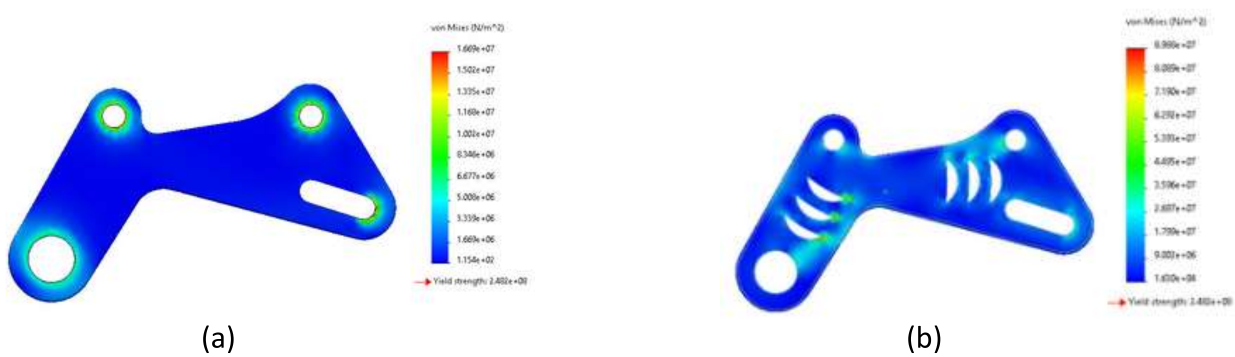
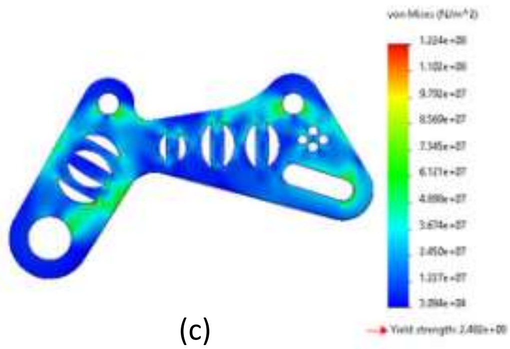


Figure 7. Voltage distribution made of aluminium 6061-T6 (SS)
(a) Initial designs, **(b)** First optimization, **(c)** Second optimization.

Figure 7 shows a comparison of the Von Misses Stress experienced by the three proposed models with aluminum alloy 6061-T6 (SS) material showing a yield strength of 2,750e+08(N/m^2). Of the three designs and shows that the stress value is highest on the surface of the hole shape. The more holes, the more critical the voltage value. The highest value of Von Misses stress for image optimization designs (A) 2,478e+04 (N/m^2), image (B) 9,650e+04 (N/m^2) and image (C) 1,224e+08 (N/m^2).





(c)

Figure 8. Voltage distribution made of cast carbon steel
(a) Initial designs, **(b)** First optimization, **(c)** Second optimization

Figure 8 shows a comparison of the Von Misses Stress experienced by the three proposed models with cast carbon steel alloy material showing a yield strength of 2.482e+08 (N/m2). Of the three designs and shows that the stress value is highest on the surface of the hole shape. The more holes, the more critical the voltage value. The highest value of Von Misses stress for image optimization designs (A) 5.779e-05 (N/m^2), figure (B) 2.827e-04 (N/m^2) and figure (C) 4.045e-04 (N/m^2).

Table 2. Weight reduction for aluminum alloy 6061-T6(SS)

Proposed designs	Mass (kg)	Mass Reduction (%)
Initial designs	0,154	
First optimization	0,144	-6,49%
Second optimization	0,138	-10,38%

Table 3. Weight reduction for Cast carbon steel material

Proposed designs	Mass (kg)	Mass Reduction (%)
Initial designs	0,445	
First optimization	0,415	-6,74%
Second optimization	0,397	-10,8%

Next, regarding the effect of material changes on the weight reduction achieved by the brake caliper bracket of the rear disc of a 50cc mini dirt bike. Two different materials are applied to the bracket, and their masses are estimated. Brackets made of structural steel can reach the heaviest masses compared to other materials. As shown in Table 2, the initial designs made of 6061-T6(SS) aluminum steel is estimated to have a mass of 0.154 kg. In the first optimization, the mass was successfully reduced to 0.144 kg, which is equivalent to a 6.49% reduction in mass compared to the initial designs. This optimization shows an increase in designs efficiency without sacrificing material strength. The second optimization gave the best results with a mass of only 0.138 kg, showing a 10.38% reduction in mass from the initial designs.

Then the mass reduction value for the carbon steel cast material is shown in table 3, the initial designs of the bracket has a mass of 0.445 kg as a reference point. Optimization efforts are made to reduce mass without sacrificing functionality. In the first optimization, the proposed designs managed to reduce the mass to 0.415 kg, which represents a reduction of 6.74% compared to the initial designs. This optimization provides increased efficiency, although the mass reduction is still at a moderate level. The second optimization resulted in a lighter designs with a mass of 0.397 kg, which provided a mass reduction of up to 10.8% from the original designs. This reduction rate indicates a more effective approach in designs, closer to the optimal value for material efficiency This optimization effort demonstrates progression in mass reduction, with higher savings potential if more innovative methods or materials are applied. The decrease in the mass of the two materials is shown in Figure 9.

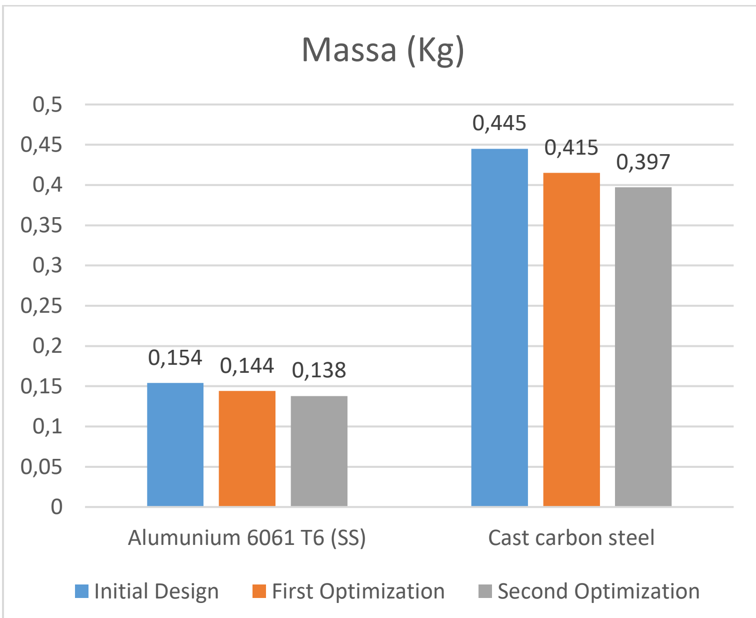


Figure 9. Mass Comparison Chart of Components Made of Alloys Aluminium 6061-T6 (SS) dan Cast carbon steel

Based on the graph, the component using Aluminum 6061-T6 (SS) material has a mass of 0.154 Kg in the initial designs, then decreases to 0.144 Kg after the first optimization, and decreases to 0.138 Kg in the second optimization. Meanwhile, components made of Cast Carbon Steel have a larger mass, which is 0.445 Kg in the initial designs. After the first optimization, the mass was reduced to 0.415 Kg, and lighter to 0.397 Kg in the second optimization. From this graph, it can be concluded that designs optimization has succeeded in reducing the mass of components in both types of materials. Aluminum 6061-T6 (SS) has a much lighter mass than Cast Carbon Steel, both before and after optimization. This shows that the use of Aluminum 6061-T6 (SS) is more advantageous in terms of reducing component weight, which can affect the efficiency of material use as well as the overall performance of the product.

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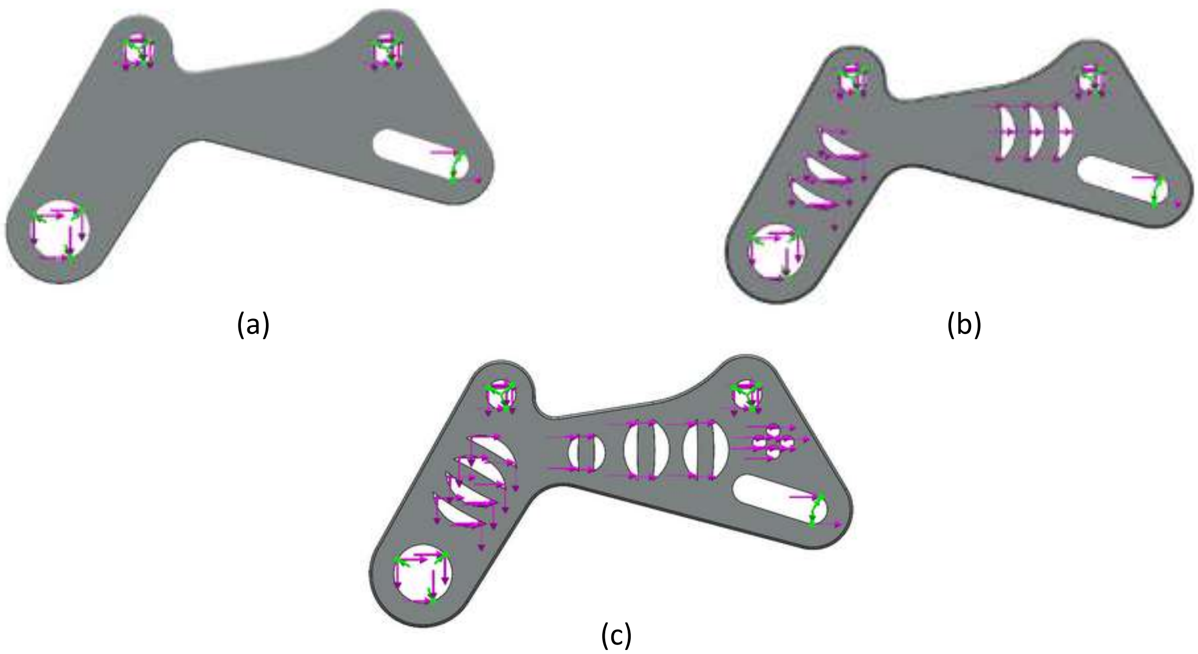


Figure 10. Directional force, pressure force, torsional force
(a) Initial designs, **(b)** First optimization, **(c)** Second optimization.

Figure 10 shows three designs variations of mechanical components with distributed forces and stresses on their surfaces. Force is a physical interaction that is able to cause changes in the motion or shape of an object. In the context of mechanics, forces are divided into several types based on their characteristics and effects. Directional style is depicted in green That is, a force that acts in one particular direction, often causing the movement of objects in the direction of that force. An example is the pull or push on the surface of an object.. This force acts perpendicular to the area of the surface being pressed, such as the pressure on the wall by the liquid in the tank. Meanwhile, Torsion force is concerned with the moment of torsion, where a force is applied to an object in a circular manner, resulting in rotation or rotation.

Table 4. Detail Vibration

Study name	Vibration
Load name	Style
Entity	7 Surface
Kind	Apply power
Value	200N, 300N
Identifiers	3

Table 4 presents information related to vibration studies in a given analysis. The name of the study used is associated with a specific frequency. The applied load is named "Force" and involves a total of 7 surfaces as entities. The type of load applied is direct force. The force value is listed in Newton (N) units, which are

200N and 300N. This analysis uses the international unit (SI) system with identification number 3 listed.

Table 5. Hinge Details

Study name	Vibration
Load name	Hinge
Entity	4 Surface
Kind	Hinge
Identifier	1

Table 5 contains details of the components used in a particular study. The name of this study is related to the frequency that indicates the presence of a hinge. The found load involves 4 surfaces as entities. The type used is a fixed hinge. This data is also equipped with an identifier given an identification number of 1. Statistical Results for Aluminum 6061-T6 (SS)

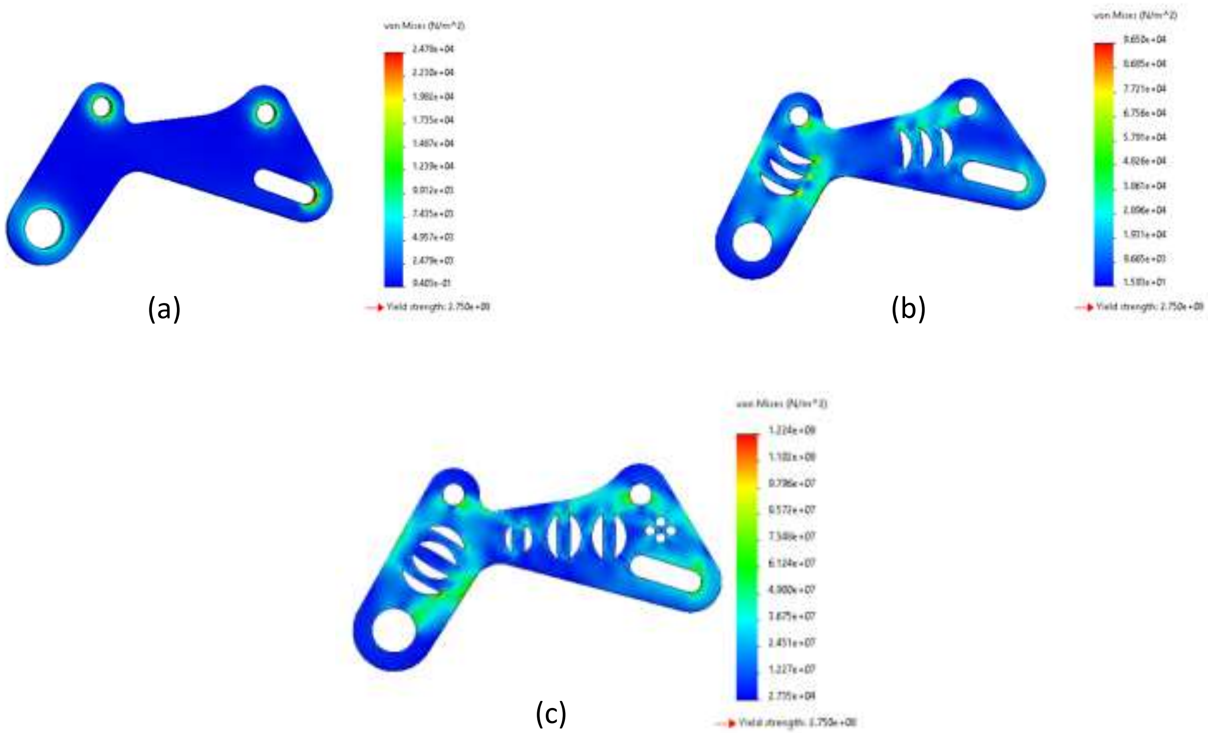


Figure 11. Von Misses Stress Analysis of Aluminum 6061-T6 (SS) Material
(a) Initial designs, **(b)** First optimization, **(c)** Second optimization.

Figure 11 Comparison of stress analysis experienced by the three proposed models with 6061-T6 (SS) aluminum alloy material in the initial designs maximum stress is 2,750e+08 MPa. Most voltages are in the blue to red color range, which is between 9,403e-01 N/m² to about 2,478e+04 N/m². The first optimization of the maximum voltage is 2,750e+08 MPa. Most voltages are in the blue to red color range, which is between 7,735e+04 N/m² to about 3,597e+07 N/m². The optimization of both the maximum voltage is 2,750e+08 MPa. Most voltages are in the blue to red color range, which is between 2,735e+04 N/m² to about 1,224e+08 N/m².

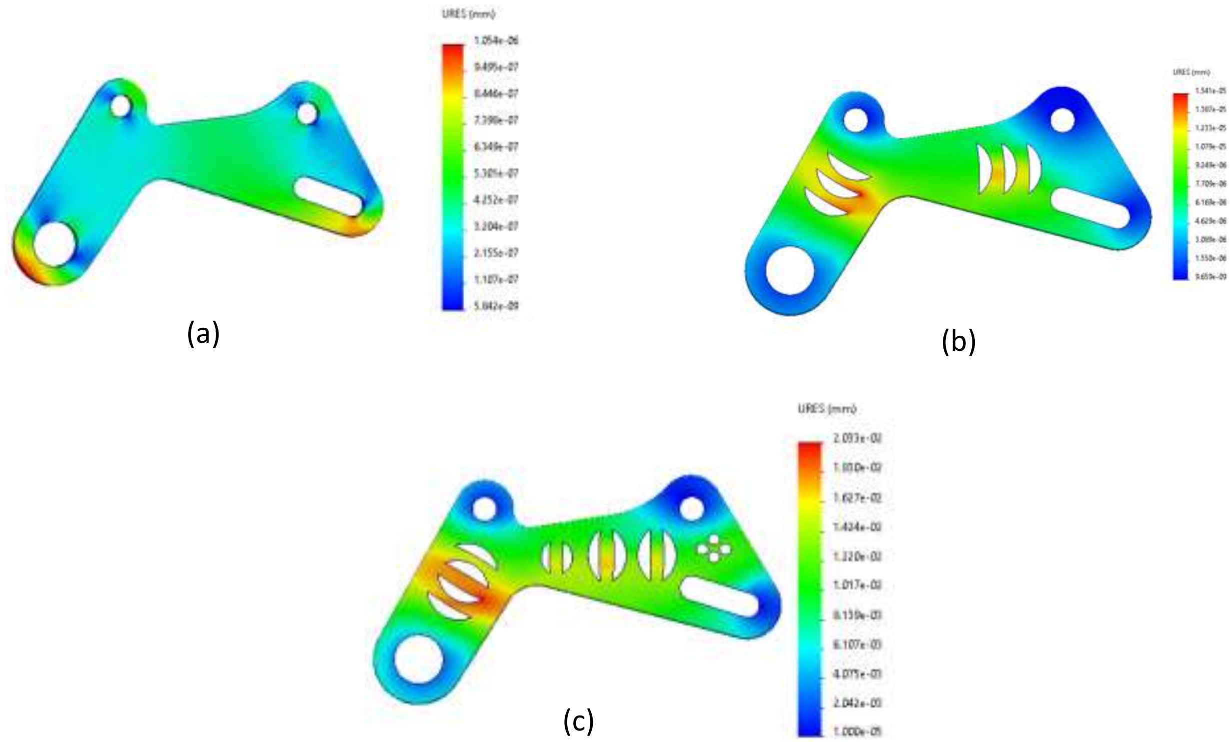


Figure 12. Simulation of analysis of movement displacement results
On aluminum material 6061-T6 (SS)
(a) Initial designs, **(b)** First optimization, **(d)** Second optimization.

Figure 12 comparison of the displacement experienced by the three proposed models with 6061 T6 (SS) aluminum alloy material in the initial designs is that the maximum displacement value of the red color is 9.495e-07 to 1.054e-06. Meanwhile, the minimum displacement of blue is 2.155e-07 to 5.847e-09. The first optimization of the maximum displacement value of the red color is 7.623e-03 to 8.466e-03. Meanwhile, the minimum displacement of blue is 1.716e-03 to 2.871e-05. The second optimization of the maximum displacement value of the red color is 1.830e-02 to 2.033e-02. Meanwhile, the minimum displacement of blue is 4,075e-03 to 1,000e-05.

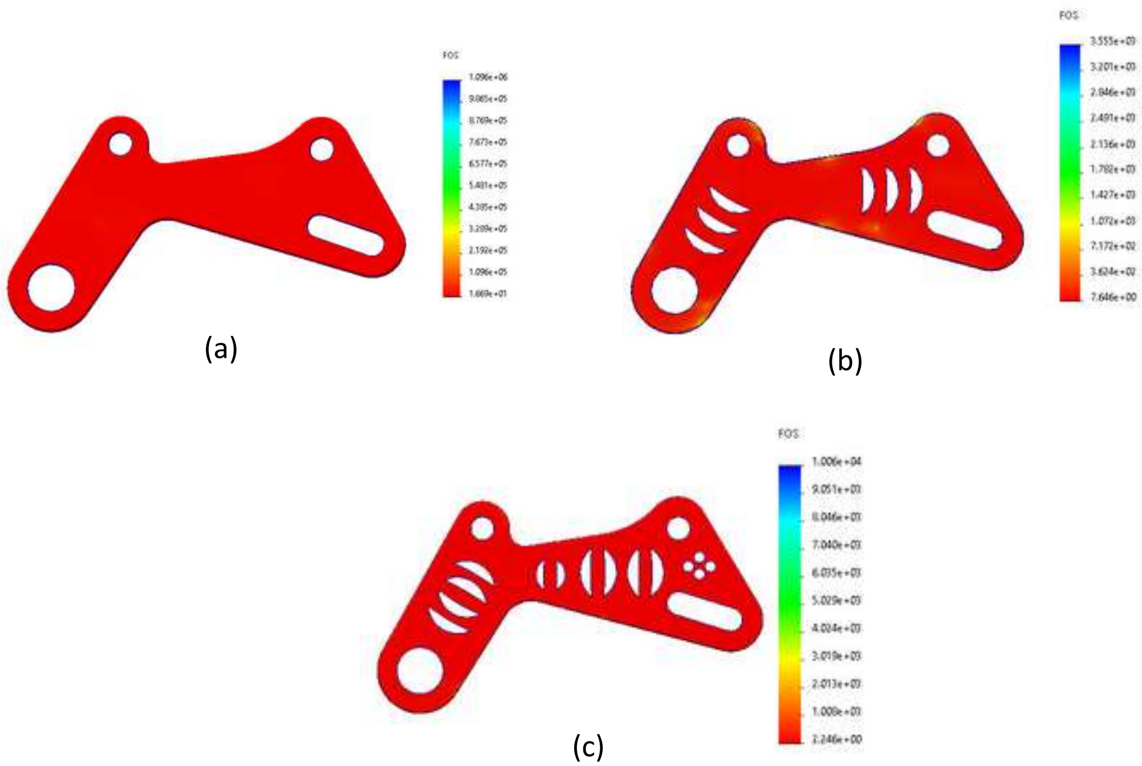
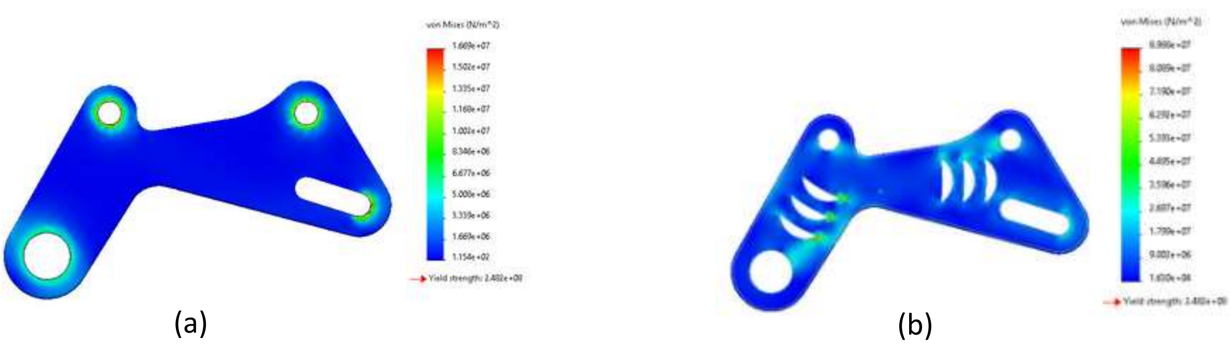
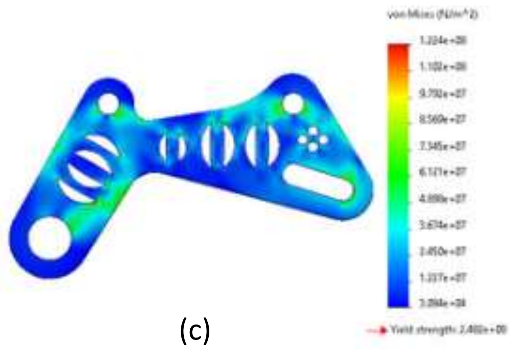


Figure 13. Simulation of the analysis of the results the safety factor on aluminum 6061-T6 (SS) material **(a)** Initial designs, **(b)** First optimization, **(c)** Second optimization.

Figure 13 Comparison of the Safety Factor experienced by the three proposed models with 6061-T6 (SS) aluminum alloy material in the initial designs shows a distribution of FOS values with gradations ranging from blue to red ranging from 1.096e+06 to 1.6690e+01. The first optimization shows a distribution of FOS values with gradations ranging from blue to red ranging from 3,555e+03 to 7,646e+00. The second optimization shows a distribution of FOS values with gradations ranging from blue to red ranging from 1,006e+04 to 2,246e+00.

Hasil Statistic Material Cast Carbon Steel.

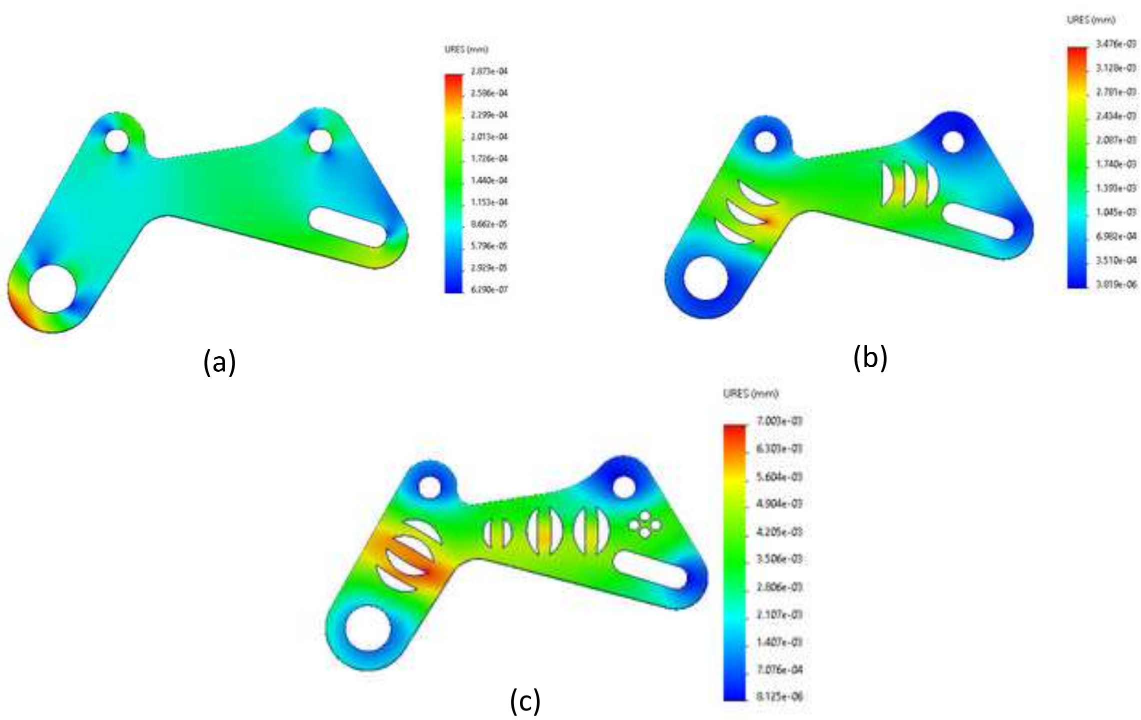




(c)

Figure 14. Simulation Von Misses Stress analysis results on cast carbon steel material **(a)** Initial designs, **(b)** First optimization, **(c)** Second optimization.

Figure 14 Comparison of stress analysis experienced by the three proposed models with cast carbon steel alloy material at the initial designs maximum stress is 2,482e+08 MPa. Most voltages are in the blue to red color range, which is between 1,154ee+02 N/m² to about 1,669e+07 N/m². The first optimization of the maximum voltage is 2,750e+08 MPa. Most voltages are in the blue to red color range, which is between 7,735e+04 N/m² to about 3,597e+07 N/m². The optimization of both the maximum voltage is 2,750e+08 MPa. Most voltages are in the blue to green color range, which is between 3,084e+04 N/m² to about 1,224e+08 N/m².



(a) (b) (c)

Figure 15. Simulation of analysis of movement displacement results Pada material cast carbon steel

(a) Initial designs, **(b)** First optimization, **(c)** Second optimization.

Figure 15 Comparison of the displacement experienced by the three proposed models with 6061 T6 (SS) aluminum alloy material in the initial designs is that the maximum displacement value of the red color is 2.586e-04 to 2.873e-04. Meanwhile, the minimum displacement of blue is 5.796e-05 to 6.290e-07. The first optimization of the maximum displacement value of the red color is 3.128e-03 to 3.476e-03. Meanwhile, the minimum displacement of blue color is 3,510e-04 to 3,819e-06. The second optimization of the maximum displacement value of the red color is 6.303e-03 to 7.003e-03. Meanwhile, the minimum displacement of blue color is 1,407e-03 to 8,125e-06.

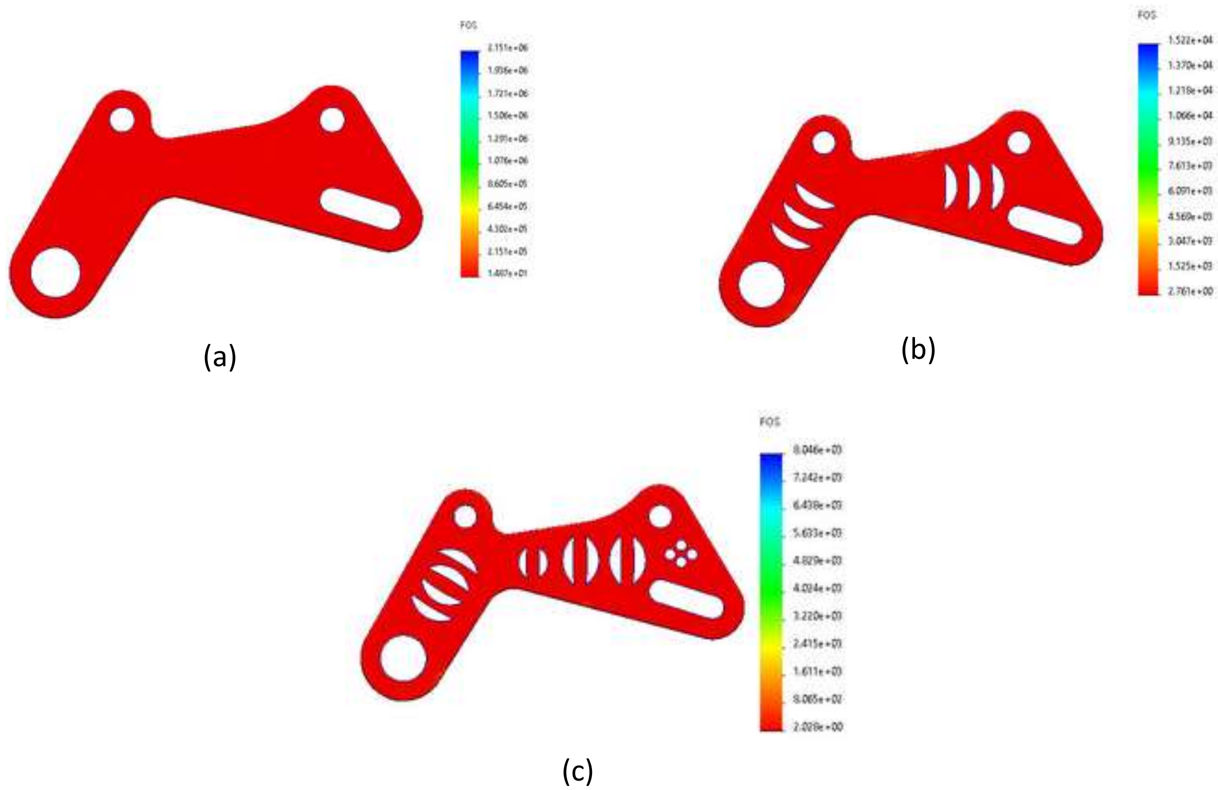


Figure 16. Simulation of analysis FOS designs results
Pada material cast carbon steel
(a) Initial designs, **(b)** First optimization, **(c)** Second optimization

Figure 16 Comparison of the Safety Factor experienced by the three proposed models with 6061 T6 (SS) aluminum alloy material in the initial designs shows a distribution of FOS values with gradations ranging from blue to red ranging from 2.151e+06 to 1.4870e+01. The first optimization shows a distribution of FOS values with gradations ranging from blue to red ranging from 1,552e+04 to 2,761e+00. The second optimization shows a distribution of FOS values with gradations ranging from blue to red ranging from 8,046e+03 to 2,028e+00.

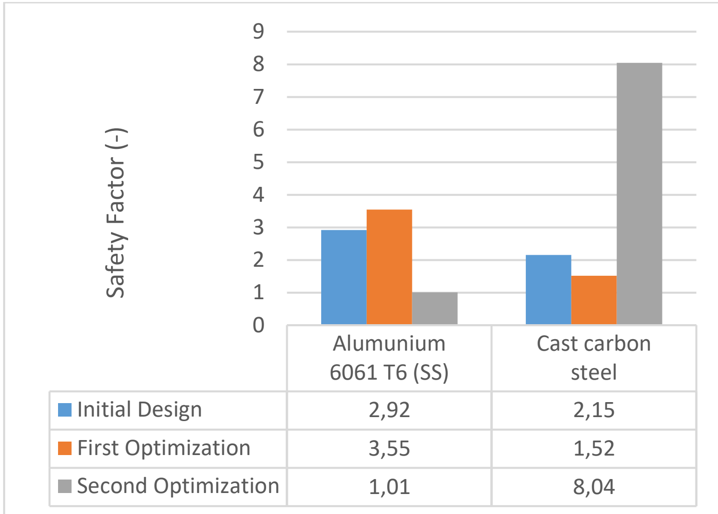


Figure 17. Safety factor chart table for three components different with three different materials

Different materials produce different safety factor values for the same component. Figure 17 shows the change in the value of the safety factor in dynamic loading of 300 N of the two components due to material changes. It can be seen that the use of cast carbon steel alloy produces the highest safety factor value of 8.04 among other materials. The initial designs made with 6061 T6 (SS) aluminum alloy has a safety factor value of 2.92. This is followed by a cast carbon steel alloy with 2.15. In this case, the values are almost the same, only slightly different factor values are about 25%. The first optimization designs made from 6061 T6 (SS) aluminum has a safety factor value of 3.55. This value is also almost three times more than that cast carbon steel alloy has a safety factor value of 1.52. Meanwhile, the second optimal designs made of 6061 T6 aluminum alloy (SS) only has a safety factor of 1.01 and structural steel has the highest safety factor of 8.04. In this case, the use of cast carbon steel structural steel alloys provides advantages in the form of higher safety factor values regardless of the cost of the material and its own manufacture.

4. CONCLUSION

This research makes a significant contribution to the optimization of the rear disc brake caliper bracket designs for a 50 cc mini dirt bike. The study supports the selection of the most suitable materials and designs on aluminum alloy 6061-T6 and cast carbon steel, which offers an optimal combination of strength and component weight reduction.

The Von Mises stress on all three designs models varies depending on the type of material. In aluminum alloy 6061-T6 (SS), the highest stress values occur around the holes, with more holes causing the stress to become more critical. The highest Von Mises stress values for the optimized designs are 2,478e+04 N/m² designs (a), 9,650e+04 N/m² designs (b), and 1,224e+08 N/m² designs (c), with a yield strength of 2,750e+08 N/m². In cast carbon steel, a similar trend occurs, with the highest stress values of 5,779e-05 N/m² designs (a), 2,827e-04 N/m² designs (b), and 4,045e-04 N/m² designs (c), with a yield strength of 2,482e+08 N/m². Designs with fewer holes tend to be more mechanically stable.

The Factor of Safety (FOS) value changed significantly after designs optimization on aluminum alloy 6061-T6 (SS). The initial designs had a higher FOS, but after optimization, the minimum FOS value decreased, indicating an increase in the load received by the structure. designs (b), the minimum FOS values reach 2,246e+00 and 2,028e+00, indicating that the designs is getting closer to the limit of material strength, but still within the safe limit.

Designs optimization results in a significant reduction in component mass. In 6061-T6 aluminum (SS), designs (b) the mass reduction is by 6.49% and designs (c) it reaches 10.39%. In cast carbon steel, the mass reduction reaches 6.74% designs (b) and increases to 10.8% designs (c). Cast carbon steel has a greater mass than 6061-T6 (SS) aluminum, although it decreases after optimization.

This research improves the efficiency of braking system performance, reduces energy used, and supports the principle of environmental sustainability. However, this study requires further validation and comparison of the results with actual physical models as a further step.

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