The Fifth International Conference on Government Education Management and Tourism
(ICoGEMT 5)
Bandung, Indonesia, January, 24th, 2026

DISC BRAKE ANALYSIS WITH DESIGN MODIFICATION THROUGH SOLIDWORKS SIMULATION

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Abstract. *This study presents an analysis of disc brake performance incorporating design modifications evaluated through SolidWorks Simulation. The primary objective is to assess how variations in disc geometry influence stress distribution, temperature behavior, and overall structural integrity during braking conditions. A three-dimensional model of the disc brake is developed, followed by the application of Finite Element Analysis (FEA) to simulate loading and rotational conditions. Several modified design variants are tested to compare improvements in strength, heat dissipation, and deformation levels. The results indicate that specific geometric enhancements can significantly reduce stress concentration, thereby increasing braking efficiency and component durability. This research provides valuable insights for optimizing disc brake design to achieve safer and more reliable braking systems.*

Keywords: *Design Modification; Disc Brake; Finite Element Analysis; SolidWorks Simulation; Structural Analysis.*

1. INTRODUCTION

Motorcycles are widely used as a primary mode of transportation due to their affordability, efficiency, and maneuverability, particularly in urban and developing regions. As motorcycle usage continues to increase, the demand for reliable and safe braking systems becomes increasingly critical. The braking system is one of the most essential safety components of a motorcycle, as it directly influences vehicle controllability, stopping capability, and rider safety under various operating conditions. Any failure or inadequacy in the braking system may lead to severe accidents, making the structural integrity of braking components a primary concern in motorcycle engineering design.

Among the main components of a motorcycle braking system, the brake disc plays a vital role in transmitting braking forces generated by the brake pads to the wheel assembly. During braking, mechanical pressure applied by the brake caliper generates frictional forces at the disc surface, producing significant mechanical loads within the disc structure. These loads result in stress, deformation, and strain, which must remain within acceptable limits to prevent structural failure. Therefore, ensuring that the brake disc possesses sufficient mechanical strength and structural stability is fundamental to maintaining braking reliability and safety.

The structural performance of a brake disc is influenced by several factors, including material properties, disc dimensions, geometric configuration, and loading conditions. In particular, the geometric design of the brake disc has a substantial effect on how stresses are distributed throughout the structure. Modern motorcycle brake discs often incorporate holes or slots distributed across the disc surface. These geometric features alter load paths and stiffness characteristics, thereby affecting stress concentration, deformation patterns, and overall structural behavior. However, while such design modifications are widely applied in practice, their mechanical effects must be carefully evaluated to ensure that structural integrity is not compromised.

One of the most common geometric variations applied to brake discs is the modification of the number and distribution of ventilation holes. Increasing or rearranging the number of holes changes the disc's effective cross-sectional area and stiffness, which may influence its response under braking loads. On one hand, an increased number of holes may help redistribute stresses and reduce peak stress concentrations. On the other hand, excessive material removal may reduce structural rigidity, leading to higher deformation and strain. This trade-off highlights the importance of performing a detailed structural analysis to determine whether a design modification improves or degrades mechanical performance.

Traditionally, brake disc design validation relied heavily on experimental testing, which can be time-consuming, costly, and limited in terms of design iteration. With the advancement of computational tools, Finite Element Analysis (FEA) has become an essential method for evaluating the structural behavior of mechanical components under various loading conditions. FEA allows engineers to simulate realistic loading scenarios, apply appropriate boundary conditions, and predict critical mechanical parameters such as von Mises stress, displacement, equivalent strain, and factor of safety. This approach enables a comprehensive assessment of structural performance prior to manufacturing or experimental validation.

Finite Element Analysis has been extensively applied in mechanical engineering research to study the structural response of brake discs. By discretizing the brake disc geometry into finite elements, FEA enables accurate prediction of stress distribution and deformation behavior across complex geometries. The method is particularly effective for identifying regions of stress concentration, such as areas near mounting holes or geometric discontinuities. Consequently, FEA provides valuable insights into the mechanical feasibility of design modifications and supports informed decision-making during the design optimization process.

In motorcycle applications, brake discs are typically subjected to high mechanical loads during braking events, especially under emergency or repeated braking conditions. These loads must be safely sustained without exceeding the material's yield strength or causing excessive deformation. Structural failure of the brake disc, such as cracking or permanent deformation, can severely compromise braking effectiveness and pose significant safety risks. Therefore, evaluating the structural response of brake discs under representative braking pressure is essential to ensure that the design meets safety requirements.

Material selection also plays a crucial role in brake disc performance. Gray cast iron is commonly used in brake disc applications due to its favorable mechanical properties, manufacturability, and widespread industrial adoption. Its well-defined elastic behavior and strength characteristics make it suitable for structural evaluation using numerical methods. By employing a material with established mechanical properties, numerical simulations can provide reliable predictions of stress, displacement, and strain under applied loads.

Despite numerous studies on brake disc performance, many investigations combine multiple physical phenomena, making it difficult to isolate the effects of geometric modification on purely mechanical behavior. In particular, studies that simultaneously address multiple coupled effects often obscure the direct relationship between disc geometry and structural response. As a result, there remains a need for focused research that evaluates brake disc designs exclusively from a structural and mechanical perspective, without introducing additional physical variables.

A purely structural approach allows for a clearer understanding of how design geometry influences mechanical performance indicators such as stress distribution, deformation magnitude, and safety margin. This type of analysis is especially valuable for early-stage design evaluation, where mechanical feasibility must be established before considering additional performance aspects. By isolating structural behavior, engineers can determine whether a design modification is mechanically sound and suitable for further development.

This study focuses on the structural evaluation of a motorcycle brake disc by comparing two different geometric configurations: an original design with 36 ventilation holes and a modified design with 48 ventilation holes. Both designs share identical overall dimensions, material properties, and boundary conditions, ensuring that any observed differences in results are directly attributable to the change in hole distribution. The analysis is performed using SolidWorks Simulation with a static structural approach, which is appropriate for evaluating peak mechanical response under steady braking pressure.

The brake disc model used in this study represents a typical motorcycle disc with an outer diameter of 220 mm and a uniform thickness of 5 mm. These dimensions are representative of commonly used motorcycle brake discs, making the results relevant to practical applications. The braking load is applied as a uniform pressure on the disc surface corresponding to contact with the brake pads. This loading condition simulates a representative braking scenario for a 110 cc motorcycle, allowing for realistic assessment of structural behavior.

Boundary conditions are defined by constraining the disc at the mounting holes, representing its attachment to the wheel hub. This constraint configuration reflects actual mechanical support conditions during operation and ensures that the simulated response closely resembles real-world behavior. By maintaining consistent boundary conditions across both models, the study ensures a valid comparison between the original and modified designs.

The primary mechanical parameters evaluated in this study include von Mises stress, displacement, equivalent strain, and factor of safety. Von Mises stress is used to assess the likelihood of yielding under applied loads, while displacement provides insight into the overall deformation behavior of the disc. Equivalent strain is evaluated to examine localized deformation and material response, and the factor of safety is calculated to determine the margin between applied stress and material strength. Together, these parameters provide a comprehensive evaluation of structural performance.

The objective of this study is to determine whether increasing the number of ventilation holes improves the mechanical performance of the brake disc without compromising structural integrity. Specifically, the study aims to assess whether the modified design exhibits reduced stress concentration, acceptable deformation levels, and an improved factor of safety compared to the original design. By focusing exclusively on structural behavior, this research seeks to provide clear and direct insights into the mechanical implications of brake disc geometric modification.

The findings of this study are expected to contribute to the understanding of brake disc structural optimization and support the development of safer and more reliable motorcycle braking systems. The results may also serve as a reference for future research focusing on design refinement and mechanical performance evaluation of brake discs using numerical methods.

2. LITERATURE REVIEW

2.1 Motorcycle Brake Disk and Structural Function

The brake disc is a critical structural component in motorcycle braking systems, functioning as the primary medium for transmitting braking forces from the brake pads to the wheel hub. During braking, the disc is subjected to compressive and friction-induced mechanical loads that generate internal stresses and deformation. The ability of the brake disc to withstand these loads without structural failure is essential for ensuring safe and reliable braking performance.

According to Limpert (2011), the structural reliability of braking components depends on their capacity to resist mechanical stress and maintain dimensional stability under repeated loading conditions. Excessive stress concentration or deformation may lead to yielding, crack initiation, or long-term degradation of structural integrity. Therefore, a detailed structural evaluation of brake discs is necessary during the design and optimization stages.

2.2 Influence of Disc Geometry on Structural Behaviour

Disc geometry significantly affects the distribution of stress and deformation under braking loads. Modern brake discs commonly incorporate holes or slots as geometric features that modify stiffness and load paths within the structure. Satish and Prasad (2017) reported that geometric discontinuities such as ventilation holes influence stress concentration patterns, particularly near the braking contact region and mounting areas.

Suresh et al. (2018) conducted a finite element analysis on ventilated brake discs and demonstrated that increasing the number of holes can reduce maximum von Mises stress by promoting a more uniform stress distribution. However, their study also noted that additional holes reduce structural stiffness, resulting in increased displacement. These findings highlight the importance of balancing stress reduction with acceptable deformation levels when modifying disc geometry.

2.3 Finite Element Analysis in Brake Disc Evaluation

Finite Element Analysis (FEA) has been widely adopted as an effective numerical tool for evaluating the structural performance of brake discs. FEA allows complex geometries to be discretized into finite elements, enabling accurate prediction of stress, displacement, and strain under applied loads. Kumar and Singh (2020) demonstrated that FEA provides reliable structural predictions when appropriate material properties, boundary conditions, and mesh refinement techniques are employed.

Budynas and Nisbett (2015) emphasized that von Mises stress is an appropriate failure criterion for evaluating yielding behavior in ductile and semi-ductile materials, including cast iron commonly used in brake discs. In addition, displacement and equivalent strain are essential parameters for assessing overall deformation and localized material response under mechanical loading.

2.4 Material Selection for Structural Performance of Brake Discs

Material properties play a crucial role in determining the structural behavior of brake discs. Gray cast iron is one of the most widely used materials for brake disc applications due to its favorable mechanical strength, stiffness, and predictable elastic behavior. According to SAE International (2018), gray cast iron exhibits stable mechanical characteristics under compressive and shear loading, making it suitable for structural applications subjected to braking forces.

Aranke et al. (2019) reviewed brake disc materials and reported that gray cast iron remains a preferred material due to its resistance to structural failure and well-documented mechanical properties. Polati et al. (2025) investigated failure cases in gray cast iron brake discs and concluded that structural failure is primarily associated with excessive stress concentration and overloading rather than geometric instability alone.

2.5 Effect of Hole Distribution on Stress and Deformation

Several studies have examined the influence of hole distribution on the structural response of brake discs. Prasetyo and Wibowo (2021) found that modifying the number and arrangement of holes significantly affects stress concentration regions, particularly near the disc mounting holes. Their results showed that an increased number of holes can reduce peak stress values while maintaining deformation within acceptable limits.

Similarly, Chen et al. (2018) reported that additional holes interrupt continuous stress paths within the disc, leading to improved stress redistribution. However, their study also indicated that increased hole density may result in higher displacement due to reduced stiffness. These findings suggest that evaluating both stress and deformation parameters is essential when assessing the mechanical feasibility of disc design modifications.

2.6 Factor of Safety in Structural Brake Disc Design

The factor of safety (FoS) is a critical indicator of structural reliability, representing the ratio between material strength and applied stress. A higher factor of safety indicates a greater margin against failure. Sharma (2020) demonstrated that brake disc designs with optimized geometry exhibit higher factor of safety values compared to conventional designs.

Williams (2018) emphasized that maintaining an adequate factor of safety is essential for motorcycle braking components due to variations in loading conditions during operation. Designs that achieve reduced stress while maintaining deformation within the elastic range generally exhibit improved safety margins and enhanced structural reliability.

2.7 Research Gap and Contribution of the Present Study

Based on the reviewed literature, it is evident that disc geometry, material selection, and mechanical loading conditions significantly influence the structural performance of motorcycle brake discs. Although numerous studies have investigated brake disc behavior using finite element methods, many combine multiple physical phenomena, making it difficult to isolate the direct effect of geometric modification on structural response.

Therefore, a research gap exists in studies that focus exclusively on the structural impact of hole distribution without considering additional physical effects. This study addresses this gap by conducting a purely structural finite element analysis to compare an original brake disc design with 36 holes and a modified design with 48 holes under identical conditions. By evaluating von Mises stress, displacement, equivalent strain, and factor of safety, this research provides a focused assessment of the mechanical implications of brake disc design modification.

3. RESEARCH METHODS

3.1 Research Design and Approach

This research employs a numerical simulation approach using Finite Element Analysis (FEA) to evaluate the structural performance of a motorcycle brake disc. The study is conducted as a comparative analysis between two disc brake designs: an original model with 36 ventilation holes and a modified model with 48 ventilation holes. The objective of this method is to investigate the influence of geometric modification on the mechanical behavior of the brake disc under braking pressure.

Finite Element Analysis is selected as the primary research method due to its proven effectiveness in predicting stress distribution, deformation, strain, and structural safety of mechanical components. Previous studies have demonstrated that FEA provides reliable results when appropriate material properties, boundary conditions, and mesh parameters are applied (Satish & Prasad, 2017; Suresh et al., 2018). This approach allows systematic evaluation of design modifications without extensive experimental testing.

3.2 Brake Disc Geometry and Design Model

The brake disc models used in this study were developed using SolidWorks CAD software. Both the original and modified designs have identical overall dimensions to ensure a valid comparison. The disc has an outer diameter of 220 mm and a uniform thickness of 5 mm, representing a standard motorcycle brake disc configuration commonly used in small-displacement motorcycles. Figure 1 shows the brake disc original design that we will modified on the Solidwork.

Figure 1. Original Disk Brake Design

The only geometric difference between the two models lies in the number of ventilation holes. The original design consists of 36 evenly distributed holes, while the modified design incorporates 48 holes arranged symmetrically around the disc surface. All hole diameters and mounting hole geometries are kept constant to ensure that variations in structural response are solely caused by the change in hole distribution.

3.3 Material Properties

The material assigned to both brake disc models is gray cast iron, selected from the SolidWorks material library. Gray cast iron is widely used in brake disc applications due to its favorable mechanical strength and well-documented elastic behavior (SAE International, 2018; Aranke et al., 2019).

The mechanical properties used in the simulation include Young's modulus, Poisson's ratio, yield strength, and density, all of which are defined according to standard material data. Using identical material properties for both designs ensures consistency and eliminates material-related bias in the comparative analysis.

3.4 Finite Element Model Setup

The finite element analysis is performed using SolidWorks Simulation with a Static Study configuration. This study type is appropriate for evaluating peak structural response under steady mechanical loading conditions, where dynamic and inertial effects are neglected. Static analysis has been widely applied in brake disc structural evaluations to assess stress and deformation behavior (Kumar & Singh, 2020).

The braking load is applied as a uniform pressure on one side of the disc surface, representing the contact area between the brake pad and the disc. The applied pressure magnitude corresponds to braking conditions representative of a 110 cc motorcycle. This loading condition ensures realistic simulation of braking force transmission without introducing additional physical effects.

3.5 Boundary Condition and Constraints

Boundary conditions are defined by applying fixed geometry constraints at the disc mounting holes. These constraints restrict all translational and rotational degrees of freedom, simulating the attachment between the brake disc and the wheel hub. This boundary condition setup reflects actual operating conditions and has been commonly adopted in previous brake disc FEA studies (Suresh et al., 2018; Sharma, 2020).

By maintaining identical boundary conditions for both disc designs, the study ensures that differences in simulation results arise solely from geometric modification rather than constraint variation.

3.6 Mesh Generation

Mesh generation is conducted using a curvature-based meshing strategy to ensure adequate element refinement in regions with complex geometry, such as ventilation holes and mounting areas. An average element size of 2 mm is applied to balance computational efficiency and numerical accuracy.

Mesh refinement is particularly important for capturing stress concentration around holes, which significantly influences structural response. Consistent mesh settings are applied to both models to ensure comparability of results, as recommended by Budynas and Nisbett (2015).

3.7 Evaluation Parameters

The structural performance of the brake disc designs is evaluated based on several key mechanical parameters:

1. Von Mises stress used to assess yielding risk under applied braking pressure
2. Displacement used to evaluate overall deformation behavior
3. Equivalent strain used to analyze localized material response
4. Factor of safety calculated to determine the margin between applied stress and material strength

These parameters are widely accepted indicators for evaluating the structural reliability of mechanical components (Budynas & Nisbett, 2015; Williams, 2018).

3.8 Analysis Data Procedure

The simulation results for both designs are extracted and analyzed using SolidWorks Simulation post-processing tools. Maximum values of stress, displacement, and strain are identified and compared to evaluate the effect of hole distribution on structural behavior. The factor of safety is calculated based on the ratio of material yield strength to the maximum von Mises stress obtained from the simulation.

By comparing the results under identical conditions, the study provides a clear assessment of whether the modified design offers improved structural performance relative to the original design.

4. RESULTS AND DISCUSSION

4.1 Finite Element Analysis Model and Simulation Parameters

The finite element analysis was performed using SolidWorks Simulation with a Static Study to evaluate the structural behavior of the motorcycle brake disc under realistic braking conditions. The brake disc was modeled with an outer diameter of 220 mm and a uniform thickness of 5 mm, representing a standard front disc brake configuration commonly used in 110 cc motorcycles.

The material assigned to the brake disc was gray cast iron, which is widely utilized in motorcycle braking systems due to its favorable mechanical strength, good vibration damping characteristics, and reliable performance under braking loads. The material properties were defined using the SolidWorks material library to ensure consistency in mechanical property assignment and numerical accuracy.

A Static Study was selected to represent steady braking conditions, where the applied load is assumed to be constant and dynamic as well as inertial effects are neglected. This assumption is appropriate for evaluating maximum von Mises stress, resultant displacement, and equivalent strain during normal braking events. The braking load was applied as a uniform pressure of 0.05 MPa, defined using the Pressure load feature and distributed over one braking surface of the disc to represent contact with a single brake pad.

Mesh generation was conducted using a curvature-based meshing strategy, which automatically refines elements in regions with high geometric curvature, such as the edges of ventilation holes and the inner mounting area. The average element size was set to 2 mm, providing sufficient mesh density to accurately capture local stress concentrations while maintaining reasonable computational efficiency. This meshing approach ensured stable and convergent simulation results for both disc configurations.

Boundary conditions were defined by applying fixed geometry constraints at the disc mounting holes, restricting all translational and rotational degrees of freedom to simulate the rigid connection between the brake disc and the wheel hub. All simulation parameters—including material properties, mesh settings, boundary conditions, and loading definitions—were kept identical for both the 36-hole and 48-hole disc models to ensure a fair and valid comparative analysis.

Through this standardized simulation setup, SolidWorks Simulation provided reliable predictions of the structural response of each disc brake design. The resulting distributions of stress, displacement, and strain serve as a robust basis for evaluating the effect of ventilation hole quantity on the mechanical performance and safety of the motorcycle brake disc.

4.2 Stress Distribution Analysis (von Mises Stress)

The von Mises stress distribution obtained from the finite element simulation provides a critical indication of the structural integrity of the brake disc under applied braking pressure. Von Mises stress is commonly used as a failure criterion for ductile materials such as gray cast iron, as it effectively represents the combined effect of multiaxial stress states. Figure 2 and Figure 3 shows the result of Solidwork Simulation for both original design and modified design.

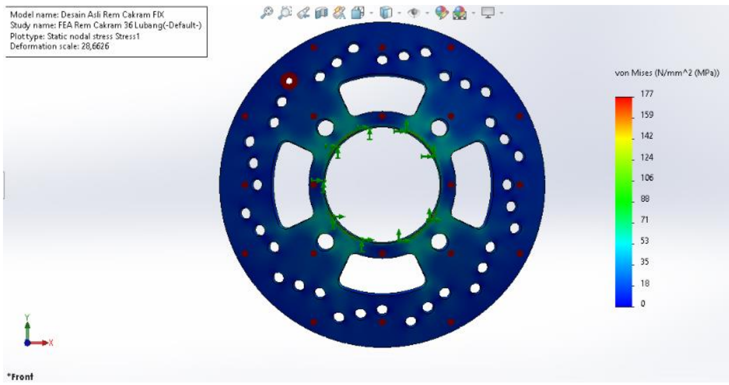

Figure 2. Von Mises Stress Ananlysis for Original Disk Brake Design

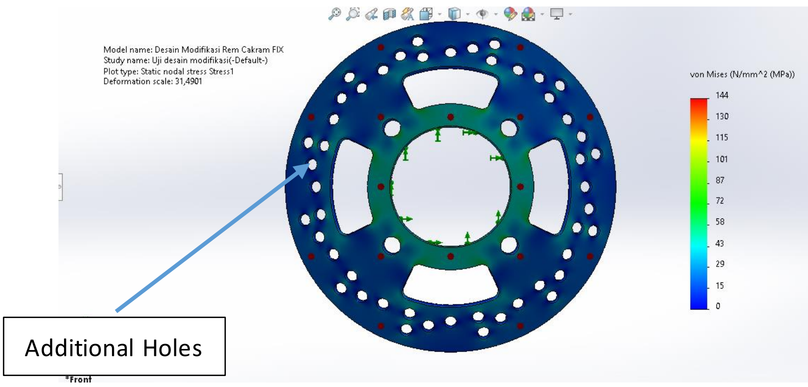

Figure 3. Von Mises Stress Analysis for the Modified Design of the Disk Brake

After simulation, we can complied the data shows by the design on to Table. Table 1 shows the result of the Von Mises Stress Comparasion.

Table 1. Von Mises Comparasion Result

Design	**Von Mises Stress (MPa)**
Original (36 Holes)	177
Modified (48 Holes)	144

Based on the results, the modified disc brake with 48 ventilation holes exhibits a lower maximum von Mises stress compared to the original 36-hole design. This reduction of approximately 18.6% indicates that the redistribution of material through additional ventilation holes leads to a more uniform stress distribution. The increased number of holes reduces localized stress concentration by allowing load paths to spread more evenly across the disc surface. This finding demonstrates that the modified design improves structural performance without increasing stress levels, despite having reduced mass. Figure 4 contains the line graph for Von Mises Stress comparasion.

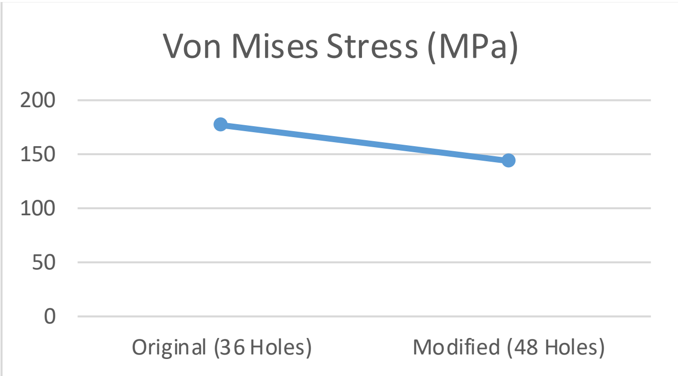

Figure 4. Von Mises Stress Graph Result

The reduction in stress can be attributed to improved load redistribution across the disc surface. The increased number of holes allows the applied pressure to be more evenly distributed, thereby reducing localized stress accumulation. Similar findings have been reported in previous studies on perforated brake discs, where optimized hole patterns were shown to decrease stress concentration without altering the overall disc geometry.

4.3 Displacement Behavior of the Brake Disc

The displacement results for both designs are presented in Figure Y. Displacement represents the global deformation of the brake disc under applied pressure and is a critical indicator of structural stiffness. Excessive displacement may lead to vibration, brake judder, or uneven pad contact during braking. Figure 5 and Figure 6 shows the result of Solidwork Simulation for Displacement Behaviour.

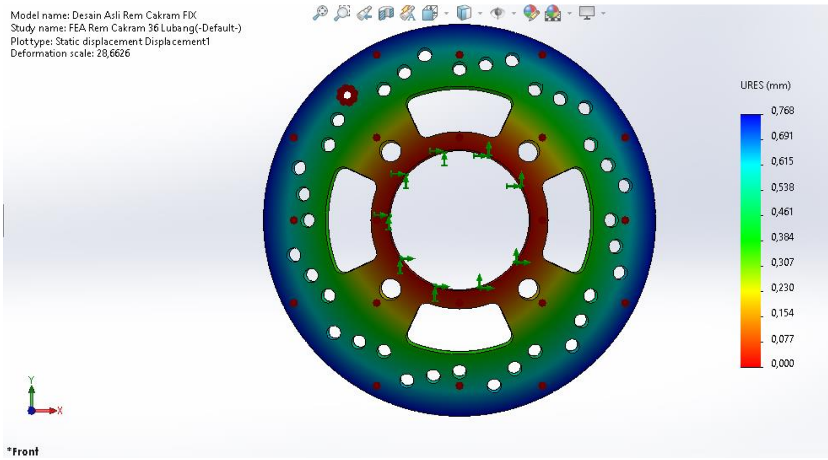

Figure 5. Displacement Behaviour Simulation for Original Design

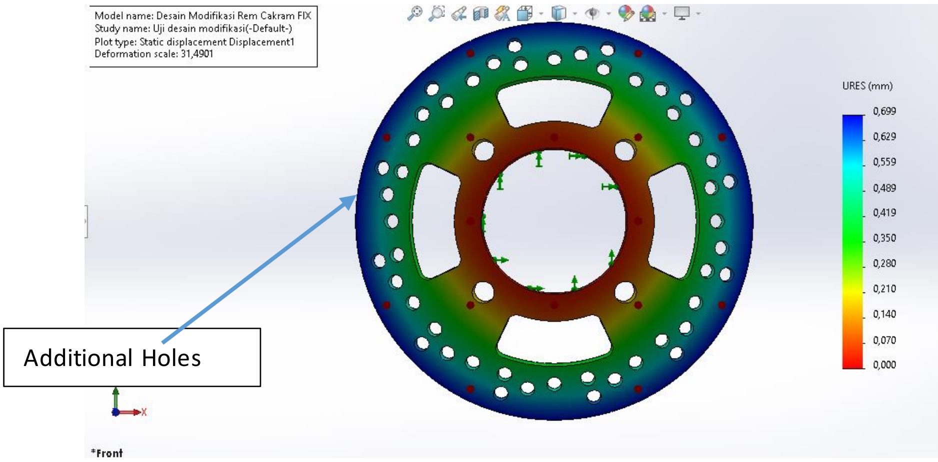

Figure 6. Displacement Behaviour Simulation for Modified Design

The results indicate that the modified disc experiences a slightly higher maximum displacement compared to the original design. This increase is primarily attributed to the reduction in material volume caused by the additional ventilation holes, which leads to lower overall stiffness. However, the displacement values for both designs remain within acceptable limits for motorcycle brake discs. The increase in displacement is considered tolerable and does not compromise the functional integrity of the disc, especially when weighed against the benefits of reduced stress and improved heat dissipation potential. Table 2 and Figure 7 presenting the result table and graph line of the Displacement Behaviour comparison.

Table 2. Displacement Behaviour Comparasion Result

Disc Brake Design	**Displacement (mm)**
Original (36 Holes)	0,768
Modified (48 Holes)	0,99

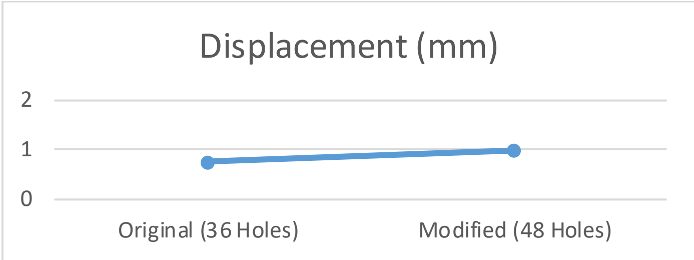

Figure 7. Maximum Displacement Graph Result

4.4 Equivalent Strain Analysis

Equivalent strain contours for both brake disc designs are shown in Figure 8 and Figure 9. Strain provides insight into the internal deformation of the material and is directly related to the extent of elastic deformation experienced by the structure.

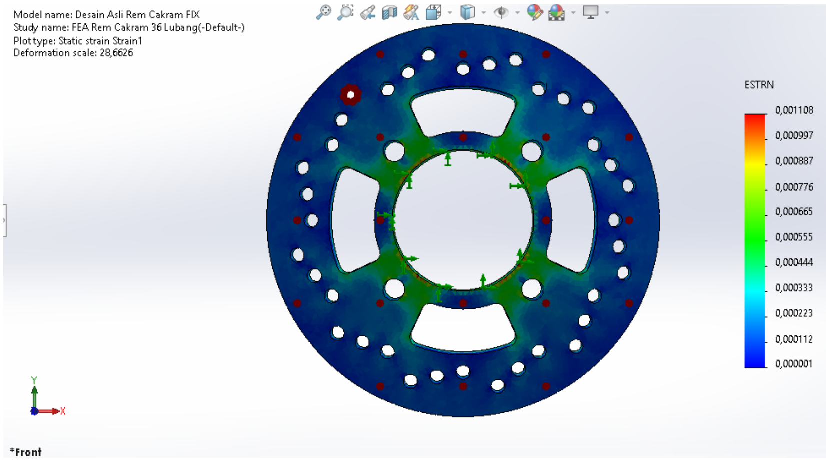

Figure 8. Equivalent Strain Analysis for Original Design

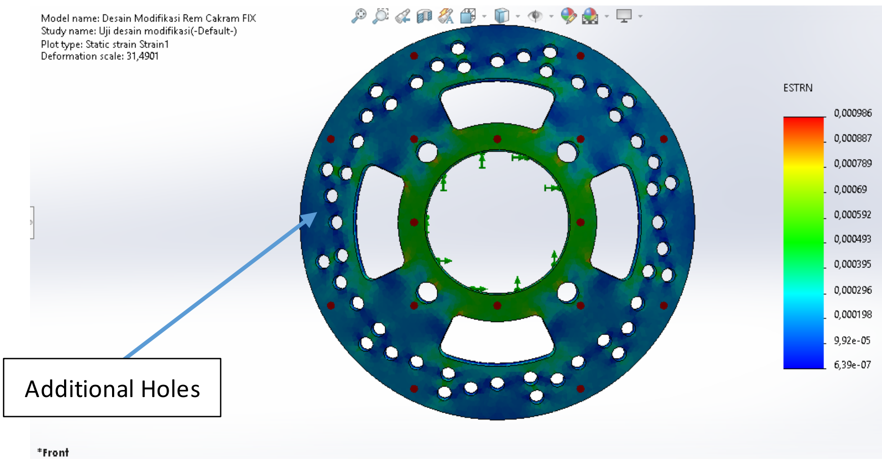

Figure 9. Equivalent Strain Analysis for The Modified Design

From the results, the modified disc shows a higher equivalent strain compared to the original disc. This behavior is consistent with the observed increase in displacement and is directly related to the reduced stiffness of the disc due to material removal. Despite the higher strain value, the strain remains within the elastic range of gray cast iron, indicating that no permanent deformation is expected under the applied braking pressure. This confirms that the modified design remains structurally safe under the simulated loading condition. Table 3 and Figure 10 shows Equivalent Strain comparison result on table and line graph.

Table 3. Equivalent Strain Comparasion Result

Disc Brake Design	Equivalent Strain
Original (36 Holes)	0,00111
Modified (48 Holes)	0,00986

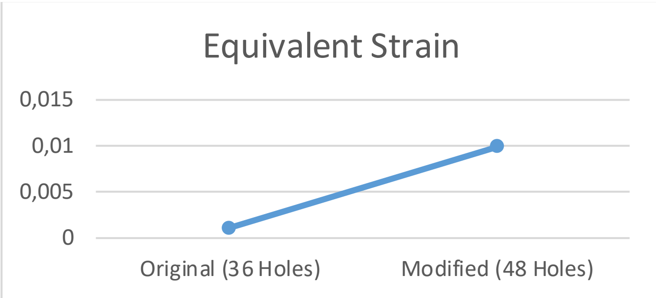

Figure 10. Maximum Strain Graph Result

4.5 Factor of Safety (FoS) Evaluation

The Factor of Safety (FoS) is calculated to assess the structural reliability of the brake disc designs. Gray cast iron was used as the material, with an assumed yield strength of 250 MPa, which is commonly reported in literature for automotive brake applications.
The FoS is calculated using the following relation:

$$FoS = \frac{\sigma_y}{\sigma_{vm}}$$

Table 4. Factor of Safety Results

Disc Design	Max Von Mises Stress (MPa)	Yield Strengh (MPa)	FoS
Original (36 Holes)	177	250	1,41
Modified (48 Holes)	144	250	1,71

The results from table 4 shows that both designs satisfy the minimum safety requirement, with FoS values greater than 1. The modified disc exhibits a higher FoS, indicating improved structural reliability despite material reduction. This confirms that the modified design not only reduces stress but also enhances safety margins under the given braking load.

4.6 Modified Design Effect on Structural Performance

This section discusses the influence of design configuration on the structural behavior of the brake disc by comparing the original and modified designs under identical loading and boundary conditions. Both models were evaluated using the same disc dimensions, material properties, mesh settings, and applied braking pressure to ensure that any observed differences in results are solely attributed to the variation in hole distribution.

The comparison reveals that the modified brake disc, which incorporates a higher number of ventilation holes, exhibits a more favorable stress response than the original design. The reduction in maximum von Mises stress observed in the modified disc indicates that the redesigned hole arrangement promotes a more uniform stress distribution across the disc surface. The presence of additional holes interrupts continuous stress paths and reduces localized stress concentrations, particularly in regions subjected to direct braking pressure.

In contrast, the original design with fewer holes shows higher peak stress values, suggesting that the stress is more concentrated in specific regions of the disc. This behavior highlights the limitation of the original design in distributing braking loads effectively. The modified design, therefore, demonstrates improved structural efficiency by redistributing stresses more evenly without introducing critical stress concentrations around the ventilation holes.

Regarding deformation behavior, the modified disc experiences higher displacement and equivalent strain compared to the original design. This increase is directly related to the change in geometric stiffness caused by the additional holes. However, the deformation remains within acceptable elastic limits, indicating that the modified design maintains adequate structural rigidity despite the increase in deformation. The controlled increase in displacement and strain reflects a design trade-off that favors stress reduction and safety improvement.

Overall, the comparative design analysis confirms that the modified brake disc configuration provides enhanced structural performance compared to the original design. The combination of lower von Mises stress, acceptable deformation levels, and improved factor of safety demonstrates that the design modification effectively optimizes the mechanical behavior of the brake disc. This section reinforces that design geometry plays a critical role in determining brake disc performance, even when material and loading conditions remain unchanged.

CONCLUSION

This study analyzed the structural performance of a motorcycle brake disc by comparing an original 36-hole design and a modified 48-hole design using finite element analysis in SolidWorks Simulation. The simulations were conducted under a braking pressure representative of a 110 cc motorcycle, with gray cast iron selected as the disc material. The evaluation focused on von Mises stress, displacement, equivalent strain, and factor of safety to assess the effectiveness of the design modification.

The results show that increasing the number of ventilation holes significantly reduces the maximum von Mises stress from 177 MPa to 144 MPa, representing an 18.6% decrease and indicating improved stress distribution and reduced stress concentration. Although the modified design exhibits higher displacement (0.99 mm) and equivalent strain (0.00986) compared to the original design, these values remain within the elastic deformation range of gray cast iron. Furthermore, the factor of safety increases from 1.41 to 1.74, demonstrating an enhanced safety margin.

Overall, the modified brake disc design provides superior structural performance compared to the original design. The reduction in stress and improvement in factor of safety outweigh the increase in deformation, confirming that the addition of ventilation holes is an effective design modification for improving the mechanical performance of motorcycle brake discs.

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