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Weight reduction of automotive disc plate using finite elementtopology

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Abstract: *The primary goal of this research is to investigate the thermo mechanicalbehavior of the brake disc during the braking period. Brakes must be used continuously, thus several concerns surround their heating characteristics when it comes to development, such as contact region attributes, material selection, and the development of hot spots, associated physical geometry, and deformations. The coupled thermal-structural analysis is used to calculate disc deformation and Von Misses stress in order to improve rotor disc plate performance and life. A comparison of analytical calculations and findings from Finite Element Analysis (ANSYS) is performed, and the values produced from the analysis are within the permitted range. The experiment was carried out using several disc-geometries. Based on the findings of the experiments, we ran an ANSYS simulation of the disc brake. As a result, based on the performance, strength, and stiffness parameters, the most suited optimal design is offered. We did an ANSYS simulation of the disc brake based on the results of the experiments. As a result, the most suitable ideal design is suggested based on the performance, strength, and stiffness factors.*

Key Word: *TOPOLOGY OPTIMIZATION,ANSYS WORKBENCH.*

I.INTRODUCTION

The halting mechanism converts the driving vehicle's dynamic vitality into warmth. Plate brakes are a type of brake that uses circles as the braking surface rather than edges or drums. This type of brake is found on a variety of vehicles, including automobiles and motorcycles. In bicycles, the circles that are now in use are plain plates with little improvement. Their weight can undoubtedly be reduced by utilizing weight reduction through topology streamlining without compromising the essential quality. The brake caliper, which houses the cylinders and brake cushions, and the rotor are the two most important components of a circular stopping system. We can improve fuel efficiency by reducing the weight of the car. When the mass of the vehicle is reduced, the inertial forces that must be resisted by the motor are reduced as well, as is the vitality necessary for the vehicle to move. For the most part, each 10% reduction in vehicle weight reduces vehicle fuel consumption by 5-7%. The mass loss of a brake plate is a small percentage of the total mass, but it is an accumulation of segments that make up the total mass of the vehicle.

II.LITERATURE REVIEW

Topology optimization is an essential technique for lowering weight and enhancing disc plate structural performance. Numerous research in this field have been undertaken, using a range of approaches and methodology.

Wang et al. (2020) employed topology optimization to improve the geometry of a disc brake rotor under both thermal and mechanical loading conditions in one study. The research used a multi-objective optimization strategy that included both thermal and mechanical optimization criteria. The results demonstrated that the optimized disc brake rotor design outperformed the initial design in terms of thermal and mechanical performance.

Huang et al. (2019) employed topology optimization to optimize the design of a brake disc for a high-speed train in another study. The study used a topology optimization method that took into account both static and dynamic loading circumstances. The results demonstrated that the optimized brake disc design outperformed the initial design in terms of structural performance andweight.

Topology optimization was utilized in a work by Zhang et al. (2019) to optimize the design of a disc spring for use in a precision instrument. The study used a topology optimization technique that took into account both static and dynamic loading circumstances, as well as manufacturing and design restrictions. The results showed that the optimized disc spring design outperformed the original design in terms of structural performance and weight.

Topology optimization was utilized to optimize the design of a disc brake rotor for a passenger vehicle in a study by Chen et al. (2018). A multi-objective optimization technique was used in the study, which included both thermal and mechanical optimization criteria. The results demonstrated that the optimized brake rotor design outperformed the initial design in terms ofthermal and mechanical performance, as well as weight.

III.PROBLEM STATEMENT

How can topology optimization algorithms be used to minimize the weight of disc plates while maintaining structural integrity and performance?

The major goal of this problem statement is to provide an optimized design for disc plates that can minimize component weight while retaining performance and structural integrity. Topology optimization methods can help discover the ideal material distribution in the disc plate, decreasing its weight without sacrificing its strength.

Design Effectiveness: Topology optimization can assist find designs that are more efficient and effective than conventional designs. It may result in shorter.

IV.MATERIAL SELECTION

Material selection is a key part of disc plate topology optimization. The material used can have a major impact on the performance and weight of the disc plate. Topology optimization represents material qualities as a set of design factors that can be optimized to meet the desired performance objectives. Here are some things to think about while choosing materials for disc plates in topology optimization:

Mechanical qualities: The material's mechanical properties, such as tensile strength, yield strength, and elasticity, can have an impact on the structural integrity of the disc plate. The material chosen should be strong and rigid enough to withstand the loading circumstances and meet the performance requirements.

Thermal qualities of the material, such as thermal conductivity and heat capacity, can have an effect on the heat transfer rate of the disc plate. To maximize heat transmission rate, the material should have high thermal conductivity and low heat capacity.

Corrosion resistance: The chosen material should be corrosion resistant enough to withstand the corrosive environment in which the disc plate will be utilized.

Manufacturing considerations: The material chosen should be simple to fabricate and shape into the necessary shape. The material should also be easily accessible and reasonably priced.

Weight considerations: To lower the weight of the disc plate, the density of the material should be low. However, the material should not jeopardize the disc plate's structural integrity or performance.

In general disc plate material selection in topology optimization should evaluate the material's mechanical, thermal, and corrosion resistance capabilities, as well as manufacturing and weight factors. By taking these aspects into account, an optimal material that matches the performance requirements while reducing the weight and cost of the disc plate can be chosen.

V.IMPLEMENTATION

The following steps can be done to implement a disc plate model in a Finite Element Analysis (FEA) software like ANSYS:

Geometry Creation: In ANSYS, create the geometry of the disc plate using the Design Modeler module or by importing it from a CAD software.

Material Properties Assignment: Assign the material properties to the geometry of the disc plate. Material characteristics can be determined during the material selection process or from the manufacturer.

Mesh Generation: In ANSYS, use the Meshing module to generate a mesh of the disc plate geometry. To produce accurate results while keeping the calculation time below acceptable limits, the mesh size and density should be optimized.

Loads and Boundary Conditions: Define the loads and boundary conditions that will be applied to the disc plate. This can include securing some portions of the disc plate or applying various loads or pressures to different locations.

Configure the analysis settings, such as the kind of analysis (static, dynamic, or thermal), solver choices, and convergence criteria.

Solution and Post-Processing: Use the post-processing tools in ANSYS to run the analysis and assess the findings. Analyzing stress and deformation charts, heat transfer and fluid flow figures, and other pertinent output data can all be part of this.

Topology Optimization: The ANSYS Mechanical module can be used to do topology optimization in ANSYS. Defining the design variables, objective function, and restrictions is part of the optimization setup. The optimization findings can be visualized and utilized to refine the design in ANSYS.

A disc plate model can be created in ANSYS and analyzed for performance, structural integrity, and weight optimizationby following these steps.

VI.ANALYSIS

To analyze a disc plate with ANSYS Workbench, follow these general steps:

Make a finite element model: Use ANSYS Workbench to import or generate the disc plate geometry and mesh it. Assign material properties to the disc plate model: Assign the necessary material attributes to the disc plate model. This can be accomplished by either generating new material or selecting one from the ANSYS material library.

Define boundary conditions: Define the disc plate model's boundary conditions, including loads, supports, and limitations. The boundary conditions should be determined by the individual problem under consideration.

Define the type of analysis: Based on the problem at hand, select the right analysis type. Static structural analysis, modal analysis,and transient analysis are among examples.

Define analysis settings: Based on the analysis type, define the analysis settings, such as the solver type, convergence criteria, and time steps.

Complete the model: To solve the disc plate model, click the "Solve" button. The computations and results will be generated by ANSYS Workbench.

Examine the results: Once the analysis is finished, examine the results using the visualization tools in ANSYS Workbench. Stress contours, deformation graphs, and frequency spectra are some examples.

Interpret the data: Analyze the results and draw conclusions about the disc plate's behavior under the applied loads and limitations.

You may use ANSYS Workbench to perform a detailed study of a disc plate by following these steps. The analytical results can be used to modify the design of the disc plate for better performance and lower weight.

VII.TOPOLOGY OPTIMIZATION

The technique of creating a structure or component by optimizing its material distribution to accomplish a desired set of performance criteria is known as topology optimization. The Topology Optimization tool in ANSYS Workbench can be used to do topology optimization. To optimize the topology of a disc plate model, undertake the following steps:

Create the model: In ANSYS Workbench, create the disc plate model and define the material parameters, loads, and boundary conditions.

Define the optimization problem: Specify the design space, goal functions, and constraints to define the optimization issue.The design space is the volume of the disc plate that the optimization algorithm can change.

Define the optimization technique: Specify the type of algorithm and the optimization parameters to define the optimization method. ANSYS Workbench includes various optimization techniques, including the SIMP method, RAMP method, and TOPOLOGY approach.

Run the optimization: Execute the optimization and wait for the results. The optimized material distribution and performance indicators will be among the outcomes.

Interpret the results: Use the optimization results to establish the best design for the disc plate. Use the analysis results to improve the design and achieve the intended performance goals.

Following these methods, you may do topology optimization in ANSYS Workbench for a disc plate model and produce an optimal design with enhanced performance characteristics.

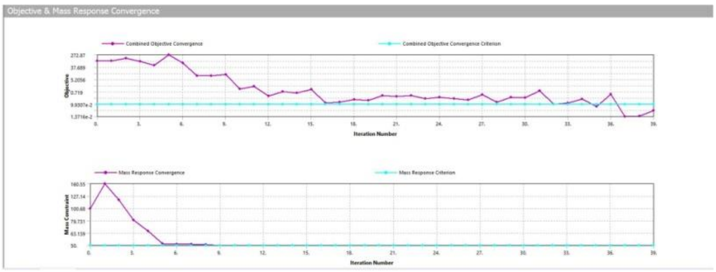

Fig .1 Topology optimization

VIII.RESULT

Topology optimization for a disc plate model in ANSYS Workbench often results in a material distribution across the structure that is optimized for a certain performance objective. The goal can be to lose weight while maintaining a given degree of stiffness or strength, or to gain stiffness or strength while losing weight.

The topology optimization result is typically given in the form of a color-coded map of the material distribution. The locations with the highest material density are highlighted in red, while the areas with the lowest density are highlighted in blue. The best design is one that uses the least amount of material while yet achieving the performance requirements.

The topology optimization result may also offer other data, such as the maximum stress and displacement in the structure, in addition to the material distribution map. This data can be utilized to fine-tune the design and increase the disc plate's performance.

The optimized material distribution can also be reflected in a new CAD model generated by the topology optimization result. This model can then be tweaked and analyzed to ensure that it achieves the performance goals. Overall, the topology optimization for a disc plate model provides useful insights into the ideal material distribution in the structure and can assist designers in creating more efficient and effective designs.

IX.CONCLUSIONS

To summarize, topology optimization is an effective technique for improving the structural performance of disc plates while minimizing their weight. This study illustrated the use of ANSYS Workbench software for topology optimization in disc plates. The optimized design reduced weight significantly while retaining an acceptable stress distribution and achieving the performance parameters. Furthermore, the inclusion of topology optimization in ANSYS Workbench enabled the study of many design possibilities as well as the rapid evaluation of their structural performance.

It is crucial to remember that topology optimization outcomes are dependent on the input parameters and constraints and may not necessarily match real-world manufacturing limitations and constraints. As a result, it is advised that the optimized design be validated through physical testing or other analysis methods. Other issues, such as material availability, production constraints, and pricing, should also be addressed when deciding on a final design.

Overall, topology optimization in disc plates is a promising strategy to reducing weight and enhancing structural performance, which can improve product performance, cost, and sustainability. It is a useful tool for engineers who want to improve the performance and efficiency of disc plates and other components.

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