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Modeling and Analysis of Automobile Drum Brake Return Spring for Improvement of Braking Performance

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ABSTRACT

This paper focuses on the optimization of automobile drum brake systems with particular emphasis on the return spring. Utilizing brake shoes as the primary object of study, a three-dimensional model of the brake shoe is established using CAD 2016 software. The driving force exerted by the cam on the brake drum and the spring at the brake back position are calculated. Subsequently, static analysis of the return spring structure is conducted using ANSYS Workbench software, enabling the determination of stress and deformation in both the brake drum and the return spring under static load conditions.

Through optimization of the brake drum and spring structure, significant improvements are achieved. The maximum stress in the optimized brake shoe is reduced by 30.88%, showcasing the efficacy of the proposed methodology. These findings serve as a theoretical foundation for the structural design and optimization of brake shoes, contributing to advancements in automotive brake technology and enhancing overall braking performance and safety.

Keywords: Automobile, Drum Brake, Return Spring, Modeling, Analysis, Optimization

INTRODUCTION

The automotive industry continuously strives to enhance vehicle safety and performance, with braking systems representing a critical area of focus. Drum brakes, a traditional braking mechanism, remain prevalent in many vehicles due to their reliability and cost-effectiveness. Within the drum brake assembly, the return spring serves a crucial function by retracting the brake shoes after a braking event, ensuring smooth wheel rotation and effective brake release. However, the design and performance of the return spring significantly influence overall braking efficiency and safety.

Fig 1: Brake drum and its parts

This project aims to address these challenges by undertaking a comprehensive study on the modeling and analysis of automobile drum brake return springs. Leveraging AutoCAD 2016 software, the project focuses on developing detailed 2D and 3D models of the return spring, considering factors such as geometry, material properties, and mechanical behavior. By accurately simulating the interaction between the return spring and other brake components, including the brake drum and shoes, the project seeks to identify opportunities for optimization.

Furthermore, utilizing advanced simulation tools like ANSYS Workbench software enables the project to conduct static analysis, assessing the stress and deformation of the return spring under various loading conditions. Through iterative refinement and optimization of the return spring design, the project aims to improve braking performance by reducing stress concentrations and enhancing structural integrity.

Fig 2: working principle of a brake drum

Ultimately, the findings of this study are expected to provide valuable insights into the design and optimization of automobile drum brake return springs, contributing to advancements in automotive brake technology and enhancing overall vehicle safety and performance.

METHODOLOGY

CAD Modeling:

- Utilize AutoCAD 2016 software to create detailed 2D and 3D models of the drum brake assembly and return spring.
- Define geometry, dimensions, and material properties accurately.

Static Analysis with ANSYS Workbench:

Import CAD models into ANSYS Workbench for static analysis.

Apply appropriate boundary conditions and loads to simulate real world operating conditions.

Evaluate stress and deformation of the return spring and other brake components under static load conditions.

Parameter Optimization:

Adjust design parameters such as spring dimensions, coil pitch, and material properties to optimize performance.

Utilize simulation results to guide iterative refinement of the return spring design.

Validation Testing:

Conduct bench tests or real world trials to validate the performance of the optimized return spring design.

Compare experimental results with simulation predictions to ensure accuracy and reliability.

Documentation and Reporting:

Document the entire methodology, including CAD modeling techniques, simulation setups, optimization process, and validation procedures.

Prepare comprehensive reports summarizing the findings, insights, and recommendations for future reference and dissemination.

OBJECTIVES

- Develop detailed 2D and 3D models of drum brake assembly and return spring using AutoCAD 2016.
- Conduct static analysis of return spring and brake components using ANSYS Workbench to assess stress and deformation.
- Optimize return spring design by adjusting parameters such as dimensions and material properties based on simulation results.
- Validate optimized design through bench tests or real world trials, comparing results with simulations.
- Document methodology, including CAD modeling, simulation setups, optimization process, validation procedures, and findings.

SCOPE OF THE PROJECT

- Focus on modeling and analyzing the return spring within the context of automobile drum brake systems.
- Utilize AutoCAD 2016 for detailed 2D and 3D modeling of brake components and return spring.
- Employ ANSYS Workbench for static analysis to evaluate stress and deformation of the return spring under varying loads.
- Optimize return spring design parameters such as dimensions and material properties to enhance braking performance.
- Validate optimized designs through experimental testing, comparing results with simulation outcomes.
- Scope includes documentation of methodology and findings to contribute to advancements in automotive brake technology.

STRUCTURE AND FUNCTION OF DRUM BRAKE

Understanding the structure, modes of operation, and interrelationships between the component parts is necessary to conduct a thorough investigation of the causes and failure modes of the observed object. The use of logical analysis that establishes the necessary and sufficient conditions for the development of the object's failure is only possible with a thorough grasp of the system's operation and all of its constituent parts, as well as an awareness of their interrelationships. The components of a drum brake are both mobile and immobile. While moving parts (drum (2)) are connected to the wheel hub, immobile components are fixed to the vehicle's supporting structure via a backing plate (1). Drum brakes use a drum and two symmetrically positioned brake shoes as their friction components. Brake activation involves the car's kinetic energy being transformed into heat by the brake shoes snuggling up against the drum; this is how the vehicle brakes. Riveting can be used to connect the metal component to the friction lining. The primary components of the rear drum brakes are:

1 – Baking plate,

2 - Drum,

3 – Brake shoe,

4 – Shoe lining,

5 - Rivet,

6 – Brake adjuster,

7 - Elements for holding the shoes,

8 - Shorter return spring,

9 - Longer return spring,

10 - Lever mechanism of the parking brake

11 – The return spring

Drum brakes can be activated hydraulically or mechanically. If the hydraulic transmission mechanism is used for the service brake on motor vehicles, the activation of the shoes is performed by hydraulic cylinders. Braking torque is proportional to the activation force of the brake, i.e., the operation pressure, and to the diameter of the brake cylinder. The brake cylinder is screw-connected to the baking plate (1), which is usually made in sheet metal forming processes with a relatively strong relief, resulting in a higher stiffness of the element. The rear brakes of the vehicles represent the executive mechanisms of the service and parking brakes of the vehicle. The activation of the parking brake is done via the lever mechanism.

RESULT AND DISCUSSION

In order to ascertain the total deformation and von-mises stress, structural analysis is carried out on the brake drum for three distinct materials in the ANSYS workbench after fixing support is assigned to the bottom and internal pressure is applied. The analysis revealed the following findings.

A. TOTAL DEFORMATION OF BRAKE DRUM

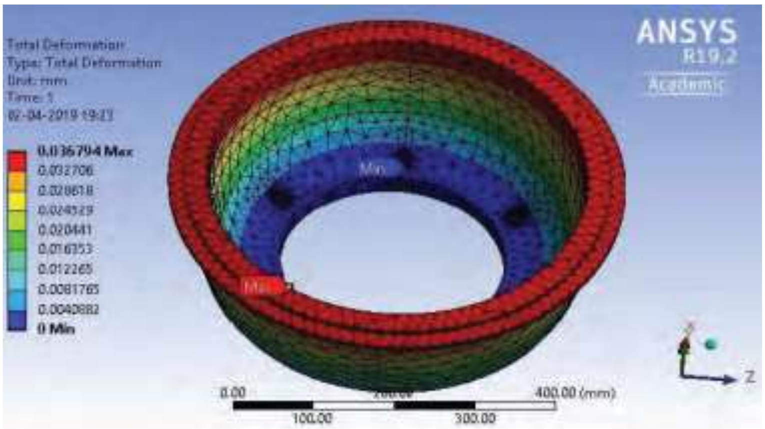

Fig 3: Total Deformation of Grey Cast Iron Material

Upon conducting structural analysis on gray cast iron material and applying a load on the brake drum, Fig. 3 displays the maximum total deformation of 0.036 mm.

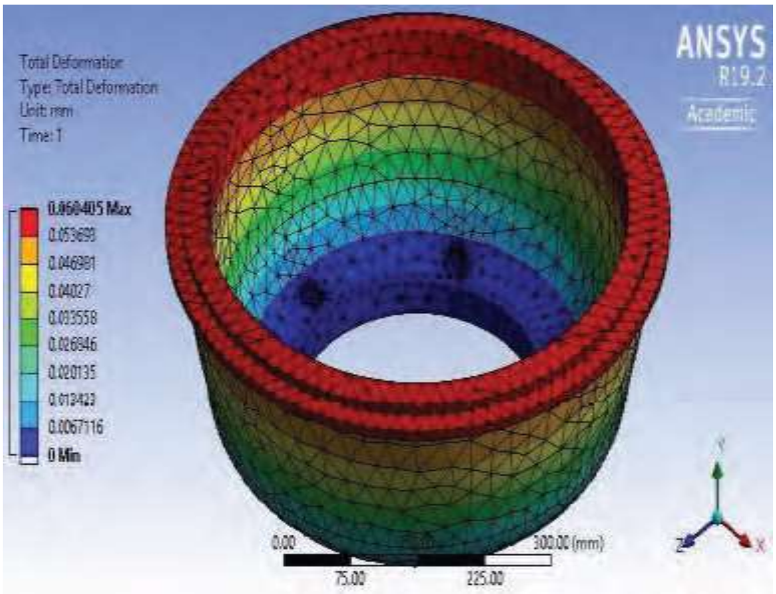

Fig 4: Total Deformation of Aluminium Alloy Material

Upon conducting a structural analysis involving the application of load on the brake drum for aluminium alloy material, Figure 4 displays a maximum total deformation of 0.06 mm.

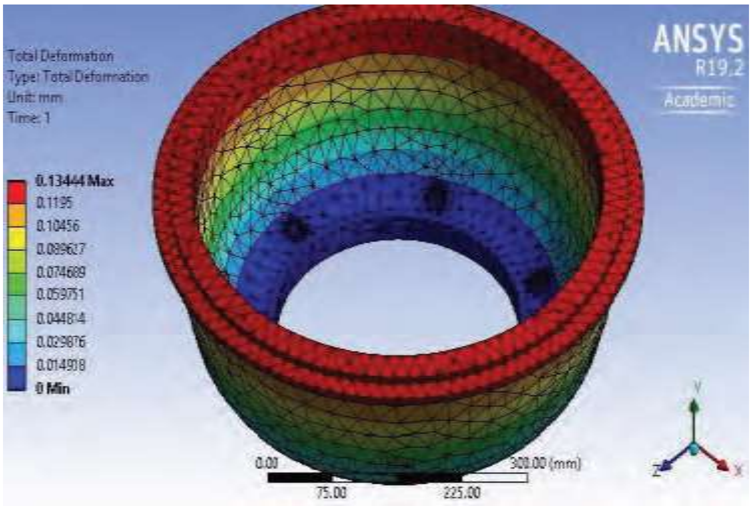

Fig 5: Total Deformation of Carbon Ceramics Material

Structural investigation on carbon ceramic material is done after the brake drum is loaded. Fig. 5 shows a maximum overall deformation of 0.133 mm.

B. VON-MISES STRESS OF BRAKE DRUM

Following structural analysis using a brake drum loaded with grey cast iron, Fig. 6 shows the highest von-Mess stress of 20.2 MPa and the minimum von-Mess stress of 0.002 MPa.

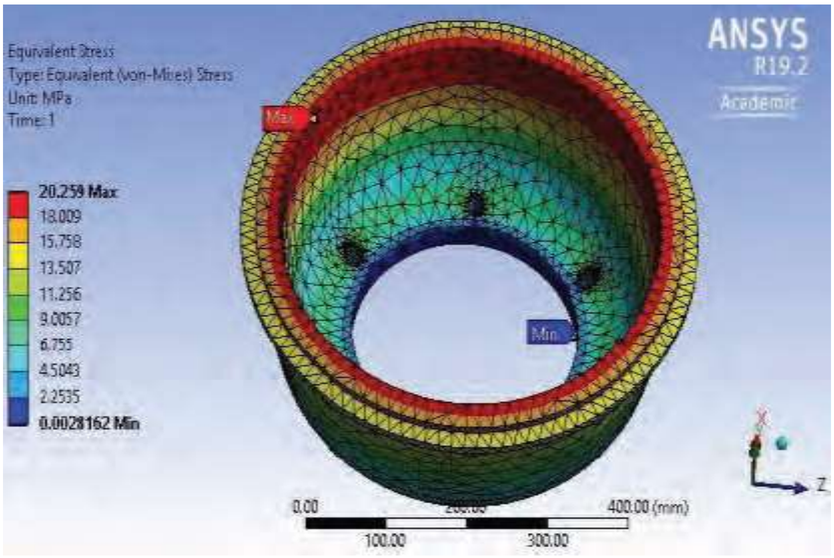

Figure 6: Von-mises Stress of Grey Cast Iron Material

The highest von-Mess stress of 20.36 MPa and the minimum von-Mess stress of 0.001 MPa are noted after the load is applied to the brake drum for aluminum alloy material from Figure 7.

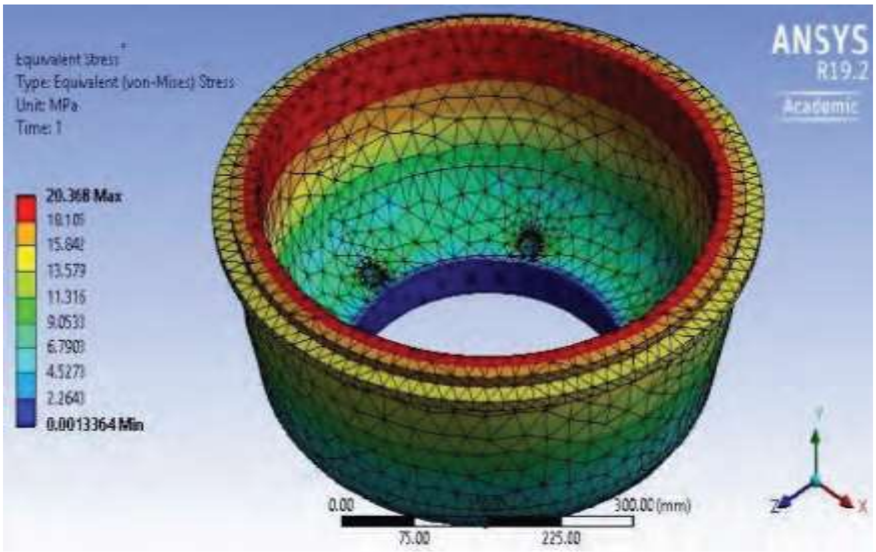

Fig 7: Von-mises Stress of Aluminum Alloy Material

Figure 8 shows that the highest von-Mess stress of 20.236 MPa and the minimum von-Mess stress of 0.003 MPa were measured after applying the load to the brake drum for carbon ceramic material.

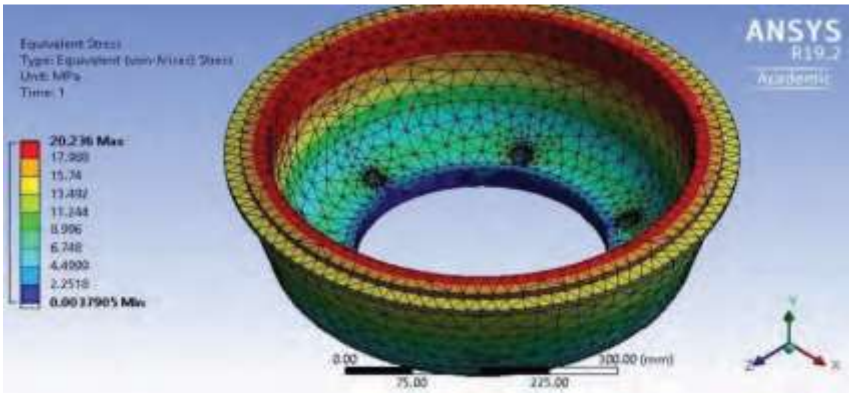

Fig 8: Von-mises Stress of Carbon Ceramics Material

Fig. 9 shows the curve of total deformation for three distinct materials.

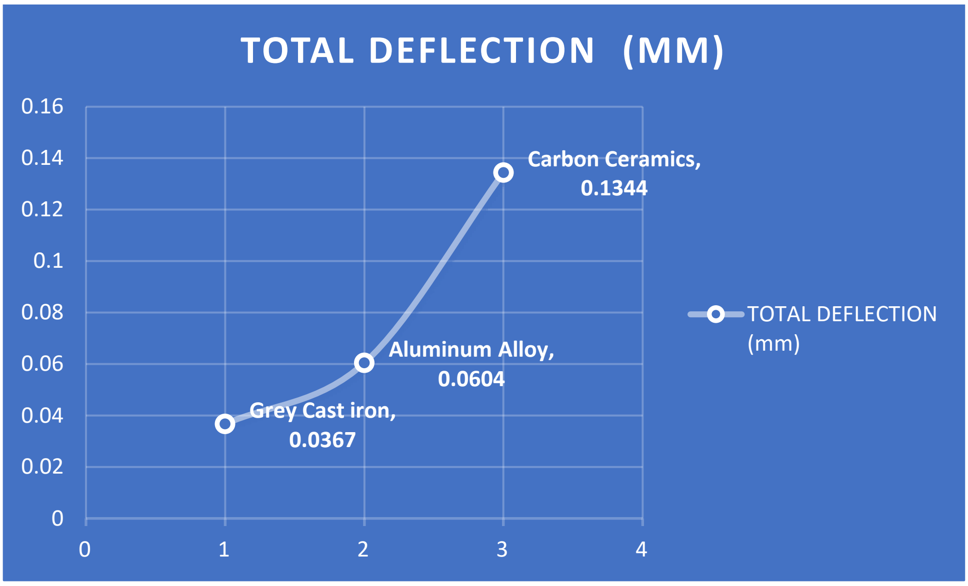

Figure 9 :Total Deformation Graph for Different Materials

Fig. 10 shows the von-Mies stress graph for three distinct materials.

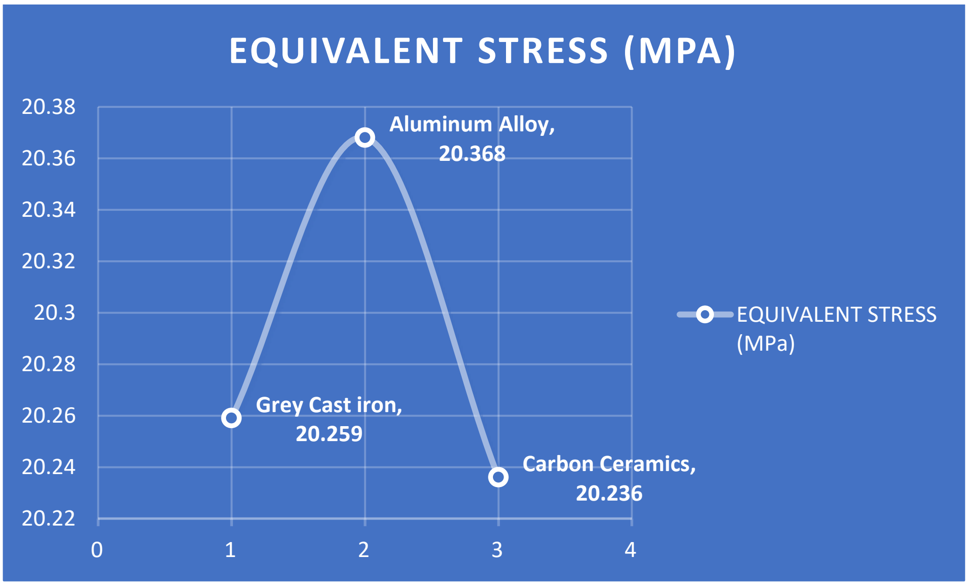

Figure 10: Equivalent Stress Graph for Different Materials

Table I shows the overall deformation in millimetres and the equivalent stress in Mpa for three different brake drum materials.

MATERIAL	**TOTAL DEFLECTION (mm)**	**EQUIVALENT STRESS (MPa)**
Grey Cast iron	0.0367	20.259
Aluminum Alloy	0.0604	20.368
Carbon Ceramics	0.1344	20.236

Table 1: Results Comparison For Brake Drum Material

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