Inboard Braking System

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Abstract—The braking system is one of the most important safety components used in vehicles and mechanical systems. The main purpose of a braking system is to reduce the speed of a moving vehicle or to stop it completely whenever required. Brakes work on the principle of friction, where the kinetic energy of a moving object is converted into heat energy which helps in slowing down or stopping the motion. In modern vehicles such as bicycles, motorcycles, and cars, disc braking systems are widely used because they provide better braking performance, faster response, and improved heat dissipation compared to traditional braking systems. The main objective of this project is to design and fabricate a Pedal Operated Disc Braking System Working Model to understand the basic construction and working principle of disc brakes. In this model, a strong frame is prepared on which bearings, axle rod, wheels, brake disc (rotor), brake caliper, brake cable, and pedal mechanism are mounted. The axle is supported by bearings which allow the wheel to rotate freely. A brake disc is fixed at the center of the axle and a brake caliper is mounted near the disc. When the pedal is pressed, the brake cable pulls the caliper mechanism and the brake pads press against the rotating disc. Due to the friction created between the brake pads and the disc surface, the speed of the wheel gradually decreases and finally the wheel stops rotating. This project helps in understanding how mechanical force applied through a pedal can control the motion of a rotating wheel. The model also explains the importance of braking systems in vehicles for safety and control. This working model is very useful for educational purposes, especially for mechanical engineering students, as it helps them understand the construction, components, and working principle of disc braking systems used in real vehicles.

Index Terms—Inboard braking system, drivetrain-mounted brakes, unsprung mass reduction, brake efficiency, thermal management, braking performance, vehicle stability, torque transmission, NVH analysis, and brake system optimization.

I. INTRODUCTION:

In modern transportation systems, safety and control of vehicles are extremely important. One of the most important systems responsible for vehicle safety is the braking system. A braking system is a mechanical arrangement used to slow down or stop the motion of a moving vehicle. Without a proper braking system, it would be very difficult to control the speed of a vehicle and prevent accidents. Therefore, braking systems play a very important role in automobiles such as bicycles, motorcycles, cars, buses, and trucks.

The basic principle of a braking system is based on friction. When two surfaces come in contact with each other, friction is produced. This friction helps in reducing the speed of a moving object. In vehicles, brakes convert the kinetic energy of the moving wheel into heat energy through friction, which gradually reduces the speed and finally stops the vehicle. The efficiency of a braking system depends on the design of the brake components and the amount of friction produced between them.

There are different types of braking systems used in vehicles such as drum brakes, disc brakes, hydraulic brakes, and mechanical brakes. Among these, the disc braking system is widely used in modern vehicles because of its higher efficiency, better heat dissipation, and improved braking performance. Disc brakes provide quicker response and better control compared to traditional drum brakes. Due to these advantages, disc braking systems are commonly used in motorcycles, cars, and high-performance vehicles.

A disc braking system mainly consists of a brake disc (rotor), brake caliper, brake pads, and a braking mechanism such as a lever or pedal. The brake disc is attached to the rotating wheel or axle. The caliper is mounted around the disc and contains brake pads. When the brake lever or pedal is pressed, the brake pads are forced against the rotating disc. The friction between the brake pads and the disc slows down the rotation of the wheel and eventually stops it.

The main aim of this project is to design and fabricate a Pedal Operated Disc Braking System Working Model. This project helps in understanding the basic construction and working principle of disc braking systems in a simple and practical way. In this model, a frame is prepared on which bearings, an axle rod, wheels, and a brake disc are mounted. A brake caliper is fixed near the disc and is connected to a pedal mechanism through a cable. When the pedal is pressed, the cable pulls the caliper and presses the brake pads against the disc. As a result, friction is generated and the rotating wheel slows down and stops.

This project is very useful for educational purposes, especially for students of mechanical engineering. By studying this working model, students can understand how braking systems function in real vehicles. It also helps in improving practical knowledge about mechanical components such as bearings, axles, brake discs, and calipers. The project demonstrates how mechanical force applied through a pedal can be used to control the motion of a rotating wheel. Understanding braking systems is essential for designing safer and more efficient vehicles in the future.

II. LITERATURE REVIEW:

A literature review is an important part of any engineering project because it helps to understand the previous research, studies, and developments related to the topic. In the case of braking systems, many researchers and engineers have studied different types of braking mechanisms used in vehicles. Over time, braking technology has improved significantly in order to increase safety, efficiency, and performance of vehicles.

In earlier days, most vehicles used mechanical drum braking systems. Drum brakes were simple in construction and widely used in bicycles and early automobiles. In a drum brake system, brake shoes press against the inner surface of a rotating drum to produce friction and stop the wheel. Although drum brakes were effective, they had certain limitations such as heat accumulation, brake fading, and lower braking efficiency during continuous use.

Due to these limitations, engineers started developing more efficient braking systems. One of the most important advancements in braking technology was the development of the disc braking system. Disc brakes were introduced to improve braking performance and overcome the disadvantages of drum brakes. In a disc brake system, a metal disc (rotor) is attached to the wheel and a brake caliper presses brake pads against the disc to create friction. This friction reduces the speed of the rotating wheel and eventually stops it.

Several researchers have studied the design and performance of disc braking systems. Studies show that disc brakes provide better heat dissipation compared to drum brakes because the disc is exposed to air. This helps in reducing brake fading and improves braking efficiency during repeated braking. Disc brakes also provide quicker response and better control of the vehicle.

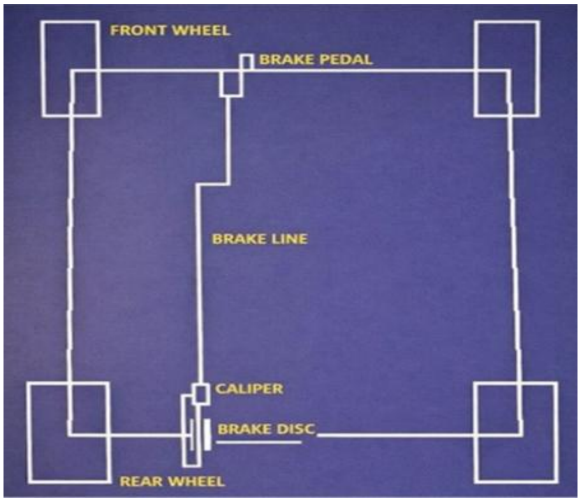
Modern braking systems are also designed with advanced technologies such as hydraulic braking systems, anti-lock braking systems (ABS), and electronic braking systems. These systems help improve vehicle safety by preventing wheel lock and maintaining vehicle stability during braking. However, the basic principle of braking still remains the same, which is the use of friction to reduce motion.

Many educational institutions encourage students to design and fabricate small working models of mechanical systems in order to understand their working principles. Working models of braking systems are very useful for demonstrating the practical application of theoretical concepts learned in mechanical engineering.

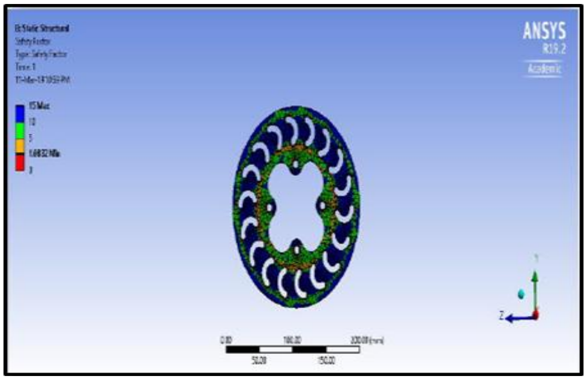
In this project, a Pedal Operated Disc Braking System Working Model is developed to demonstrate the working of a disc brake mechanism in a simple and effective way. The model consists of a frame, bearings, axle rod, wheels, brake disc, brake caliper, brake cable, and pedal mechanism. When the pedal is pressed, the cable pulls the caliper and the brake pads press against the rotating disc, producing friction and stopping the wheel. This project helps students understand the construction, working principle, and importance of braking systems in vehicles.

III. METHODOLOGY

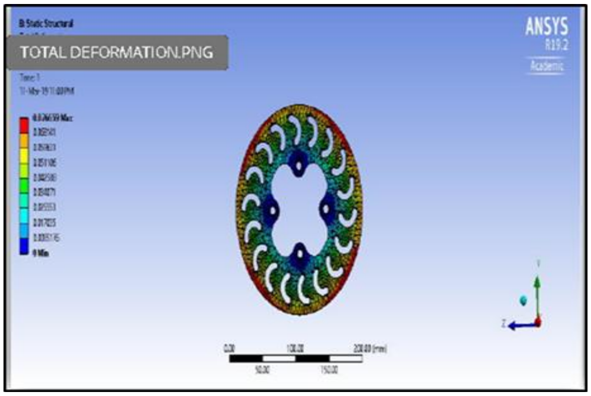
The methodology for studying the inboard braking system involves a systematic approach beginning with a detailed literature review to understand existing braking technologies and their limitations, followed by the design and modeling of an inboard brake setup using CAD software. The developed model is then analyzed using simulation tools such as Finite Element Analysis (FEA) to evaluate stress, thermal behavior, and braking efficiency under various operating conditions. Experimental validation may be conducted through prototype fabrication and testing to measure parameters like braking force, response time, heat dissipation, and vibration characteristics. The performance of the inboard braking system is then compared with conventional outboard systems to assess improvements in unsprung mass reduction, vehicle stability, and overall efficiency, leading to conclusions and possible optimization strategies.



CAD Model



Factor of Safety: 1.08



Total Deformation: 0.076 Max

IV. SCOPE OF THE PROJECT

The scope of this project on the inboard braking system encompasses a comprehensive study of its design, working principles, performance evaluation, and potential applications in modern automotive engineering. An inboard braking system refers to a configuration where the brake components, such as the disc and caliper, are mounted closer to the vehicle's differential or gearbox rather than at the wheel hub. This unique placement significantly reduces unsprung mass, which plays a crucial role in improving ride quality, handling, and overall vehicle stability. The project aims to explore these advantages in detail and assess how effectively inboard braking systems can enhance vehicle dynamics compared to conventional outboard braking systems.

The project includes the conceptual design and modeling of the inboard braking system using computer-aided design (CAD) tools. This stage focuses on determining appropriate dimensions, materials, and configurations suitable for different types of vehicles, including passenger cars, racing vehicles, and electric vehicles. Special attention is given to the integration of the braking system with the drivetrain, ensuring efficient torque transmission and minimal mechanical losses. The study also involves understanding the working mechanism of the system, including force transmission, braking response, and interaction with other vehicle subsystems.

Another important aspect of the project scope is the performance analysis of the inboard braking system. This involves evaluating parameters such as braking efficiency, stopping distance, heat generation, and thermal dissipation. Advanced simulation techniques like Finite Element Analysis (FEA) are used to analyze stress distribution, deformation, and temperature variations under different braking conditions. These analyses help in identifying potential design improvements and ensuring the reliability and safety of the system. Additionally, Computational Fluid Dynamics (CFD) may be used to study cooling performance and optimize heat dissipation mechanisms, as inboard brakes are typically less exposed to direct airflow compared to outboard brakes.

The project also includes a comparative study between inboard and conventional outboard braking systems. This comparison highlights key differences in performance, maintenance requirements, cost, and overall efficiency. By analyzing these factors, the project aims to determine the feasibility of implementing inboard braking systems in various automotive applications. Particular emphasis is placed on their use in high-performance and racing vehicles, where reduced unsprung mass can significantly improve handling and cornering capabilities. The scope may further extend to electric vehicles, where efficient braking systems can complement regenerative braking technologies.

In addition to design and analysis, the project may involve the fabrication of a prototype or a scaled model of the inboard braking system. Experimental testing can then be conducted to validate simulation results and measure real-world performance parameters such as braking force, response time, vibration, and noise characteristics. This practical approach enhances the understanding of system behavior under actual operating conditions and provides valuable insights into potential challenges and limitations.

V. CONCLUSION

This project has provided us with extensive, in-depth, and technical knowledge about the given topic. During the preparation of this project, we collected information from various reliable sources, analyzed it critically, and presented it in a well-structured and organized manner. This process helped us gain a clear understanding of both fundamental and advanced concepts.

Through this project, we were able to bridge the gap between theoretical knowledge and practical application. While studying or developing the working model, we understood the functioning of various components, their interrelationships, and the overall operation of the system. This hands-on experience significantly strengthened our understanding of the subject.

During the project work, we faced several technical, managerial, and time-related challenges. However, overcoming these challenges enhanced our problem-solving abilities, decision-making skills, and technical thinking. It also boosted our confidence and prepared us to handle real-world challenges effectively.

This project also helped us understand the importance of proper planning and systematic execution. We learned how to manage time efficiently, divide work among team members, and complete tasks within the given deadline. Teamwork played a crucial role, and it improved our communication skills, coordination, and collaborative approach.

The tools, techniques, and methodologies used in this project gave us practical exposure similar to real industrial processes. This experience will be highly beneficial for our future studies, higher education, and professional career.

Furthermore, this project encouraged us to explore new ideas and develop a habit of self-learning. It increased our curiosity and motivated us to gain deeper knowledge in the field.

In conclusion, this project has been extremely informative, beneficial, and inspiring. The knowledge, skills, and experience gained through this project will guide us in successfully completing more complex projects in the future and will contribute significantly to our academic and professional growth.

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