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A Review Paper on Disk Brake Rotor

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A B S T R A C T

A Disk brake rotor play a critical role in modern automotive braking systems, providing the essential mechanism for converting kinetic energy into thermal energy, thereby facilitating vehicle deceleration. This abstract delves into the fundamental principles, design considerations, materials, and performance characteristics of disk brake rotors. Firstly, the abstract elucidates the operating principles of disk brake rotors within the context of automotive braking systems. It explores how the rotational motion of the wheel translates into frictional forces acting on the rotor surface, generating heat that dissipates through conduction and convection. Secondly, it discusses the key design considerations influencing the efficiency and reliability of disk brake rotors. Factors such as rotor diameter, thickness, ventilation, and surface geometry are analysed for their impact on heat dissipation, wear resistance, and braking performance. Furthermore, the abstract addresses the materials commonly employed in disk brake rotor construction. Traditional materials like cast iron are contrasted with newer alternatives such as carbon-ceramic composites, examining their respective advantages in terms of weight, thermal conductivity, durability, and cost. Moreover, the abstract explores the performance characteristics of disk brake rotors under various operating conditions. It discusses phenomena such as brake fade, hot spotting, and thermal deformation, elucidating the factors contributing to rotor wear and degradation over time

Keywords: *Disk brake rotors, Automotive braking systems, Kinetic energy, Thermal energy, Deceleration, etc*

1. LITERATURE SURVEY

Ricardo A [1]: This is an article about disc brakes. It discusses the importance of disc brakes for vehicle safety. The braking system absorbs kinetic energy and converts it to heat. The disc and pads are the main parts of the braking system. Solid and ventilated discs are the two main types of disc brakes. Ventilated discs are more effective at dissipating heat. Finite Element Analysis (FEA) is a computer aided design software used to analyze disc brakes. This research project has shown that it is vital to incorporate existing computer assisted design software to predict performance, improve components and optimize the functionality of the brake system. In this way, road traffic safety and systems efficiency are achieved, which are a matter of great importance for the industry. It is vital to analyze brake systems through Finite Element Analysis (FEA), with the intention of achieving a broader vision of its performance, since the information collected reveals that the geometric characteristics of the brake and cooling ducts influence the heat dissipation.

Venkatramanan R [2]: A brake is a mechanical device which slowing or stopping a moving object or preventing its motion. This work deals with the thermal analysis of disc brake of a vehicle. Heat generation and dissipation of disc brake are analyzed. The objective of this work is to investigate and analyze the temperature distribution of rotor disc during operation using Ansys. The standard disc brake two wheelers model using in Ansys and done the Thermal analysis and also calculate the Heat flux, Temperature of disc brake model. This is to understand the pressure force and friction force on the disc brake material, which can help to reduce the accident that may happen in each day. In this research work design of a disc brake is proposed with copper liner on its brake disc, the heat transfer of existing and hybrid disc will be calculated for finding the effectiveness of heat transfer.

Deepak S. Hugar [3] the paper presented a study on the thermal analysis of disc brakes for minimizing temperature. The authors analyzed the different shapes of slots on disc brake rotors and optimized the number and shape of slots to improve the thermal conductivity of the rotor. Thermal analysis was a valuable tool in this effort, as it could help to identify and mitigate potential safety hazards. The modelling and thermal analysis in the paper were done using CATIA V5R21 and ANSYS 15 software. This software was used to simulate the behavior of the disc brake rotor and simulate the heat transfer through the rotor. The results of the simulation were used to optimize the design of the rotor and improve its thermal performance. Overall, the paper was a good example of how thermal analysis could be used to improve the safety of disc brakes. The authors did a good job of explaining the importance of thermal conductivity in disc brakes and how they could be optimized to improve braking performance. The paper also provided a good overview of the modelling and thermal analysis techniques that were used in this study**.**

A. S. Abrar Ahmed [4] the main objective of this project was to design a new brake disc rotor for the Bajaj Pulsar 150 that would reduce deformation and increase heat dissipation. The project team used Autodesk Inventor 2019 to design various shapes of ventilated holes in the brake disc rotor. The inner and outer boundaries of the rotor were preserved so that the changes were made only in the intermediate patterns between the boundaries. This

ensured that the models had the same structural boundary limits. The static structural analysis and steady state thermal analysis of the brake disc rotor International Journal of Research Publication and Reviews, Vol 4, no 9, pp 1210-1212 September 2023 1211 was done using ANSYS 19. ANSYS is a dedicated finite element package used for determining the temperature distribution, variation of the stresses and deformation across the disc brake profile. The assembly analysis method was used for static structural analysis to increase the accuracy of the results. The best of the designed brake disc rotors was selected based on the magnitude of von Mises stresses, deformation, temperature, total heat flux, and weight. The results of the study showed that the brake disc rotor with a hexagonal pattern of ventilated holes had the best performance in terms of reducing deformation and increasing heat dissipation**.**

Mr. Pravin N [5] The project investigated the design of disc brake rotors by modeling and analyzing different shapes of slots in rotors with the same outer diameter and mounting position of holes on the wheel hub. The modeling was done in Creo 2.0 and the analysis was done in Ansys 14.5. The stress level, deformation, and temperature variation were analyzed at specified load conditions. The shape optimization technique was used to find the optimum design solutions. The outer diameter, inner diameter, and mounting position of holes on the wheel hub were considered as the constraints for design. The goal was to design a rotor with minimum stress level that maintained similar structural performance as rotors that were currently commercially available. The optimal solution was found by comparing the results of the modified rotor designs with the results of the existing rotor. The optimized brake rotor was further investigated with thermal and vibrational analysis. The optimized disc heat dissipation was found to be more effective than the existing brake rotor. The vibration analysis was done by finding the mode shapes and comparing the results. Vibration is an important parameter in the braking system because squealing occurs if the natural frequency of the component goes beyond the vehicle frequency.

Swapnil R [6] the paper presented a study on the force analysis and optimization of disc brake rotors. The study was conducted by modeling and analyzing different profiles of disc brake rotors with the same outer and inner diameter as used in a Bajaj Pulsar 150. The study also included an analysis of selected disc profile number 3 for different materials, as well as a thickness analysis for the selected disc rotor material. The study found that the disc brake rotor with the optimized profile and material had a higher heat flux rate than the existing rotor. This means that the optimized rotor was able to dissipate heat more effectively, which helped to reduce thermal stress in the rotor. The reduction in thermal stress improved the performance of the disc brake, which help to reduce accidents. The study could also find that the thickness of the disc rotor had a significant impact on its performance. The thicker the rotor, the more heat it could dissipate, which led to a reduction in thermal stress. However, the thicker the rotor, the heavier it was, which could impact the performance of the vehicle. The study concluded that the optimized disc brake rotor with the selected profile and material was a significant improvement over the existing rotor. The optimized rotor had a higher heat flux rate, which helped to reduce thermal stress and improve the performance of the disc brake. The study also found that the thickness of the rotor had a significant impact on its performance, and that a thicker rotor was able to dissipate heat more effectively**.**

N.Balasubramanyamet [7] the study used finite element analysis to perform a transient analysis of the thermoelastic contact problem of disk brakes with heat generation. The heat conduction and elastic equations were solved with contact problems to analyze the thermoelastic phenomenon occurring in disk brakes. The numerical simulation for the thermoelastic behavior of disk brake was obtained in the repeated brake condition. The computational results were presented for the distribution of heat flux and temperature on each friction surface between the contacting bodies. The study also investigated the thermoelastic instability (TIE) phenomenon, which is the unstable growth of contact pressure and temperature. The influence of the material properties on the thermoelastic behaviors (the maximum temperature on the friction surfaces) was investigated to facilitate the conceptual design of the disk brake system. Based on the numerical results, the thermoelastic behaviors of carbon-carbon composites with excellent mechanical properties were also discussed. The material properties had a significant impact on the thermoelastic behaviors of disk brakes.

Sanket Darekar [8] the project investigated the design and analysis of the automotive disc brake of Bajaj Pulsar 220F. Disc brakes were subjected to very high contact pressure and intensive heating of the friction surface. The effectiveness of the braking system depended on the friction coefficient, stability during braking, and wear of the friction material. Heat dissipation was an important parameter in braking, as it affected the life of the brake disc. In this project, 3D models of disc brakes of Bajaj Pulsar 220F with the same diameter but different shapes and patterns of holes were prepared in CATIA software. The objective of the project was to investigate and analyze the temperature distribution of the rotor disc during braking operation using ANSYS Workbench. The application of a specified braking torque led to the generation of heat flux. The heat flux generated and the heat transfer coefficient were numerically analyzed, and then used to calculate the rotor rigidity and maximum temperature rise on the brake disc.

Mohammed Akram [9] the project used the finite element method to analyze the structural performance of a disc brake made of gray cast iron and aluminum. The disc was subjected to centrifugal loading by angular velocity and pressure loading by a caliper. The results showed that the aluminum disc had lower stress and better performance than the gray cast iron disc. The project concluded that the finite element method is a valuable tool for analyzing the structural performance of disc brakes. The results of the project were published in the journal Journal of Mechanical Engineering in 2022. The results of the project could be used to improve the design of disc brakes for improved performance and safety.

Subhasis Sarkar[10] The purpose of the current study is to investigate and analyze the temperature distribution of the rotor disk and use FEA analysis to determine the critical temperature during operation. A static thermal analysis of disk rotors is performed to evaluate and compare their performance and to analyze the temperature distribution taking into account cooling parameters (convection and radiation). Comparative studies were conducted between different materials, such as B. AMMC, asbestos and GCI

S. Manavalan [11] Braking is the process of converting the mechanical energy of a vehicle into mechanical energy that is dissipated in the form of heat. If there is no rest in the car, the driver may be placed in an unsafe position. Brakes convert friction into heat, but when the brakes get too hot, they stall because they can't dissipate enough heat. It is necessary to perform a structural analysis within the Clearance Action Thermal Analysis in ANSYS to examine the stability and stiffness behaviour of the rotor material. Results obtained with finite element simulations and smart materials are highly

recommended. Research on the shortcomings of the ANSYS Ceramic Disc Brake System software package applied to transient thermal analysis in resistive heating. Obtain a simulation of the thermal behaviour exhibited in numerous disc brake rotor materials, The basic equations for thermal conductivity are solved for 3 materials, with initial boundary conditions and thermal loads such as heat flow at the interface between the disc and pad. Here carbon material is used instead of traditional ceramic disc brakes. By adding it, it reduces heat generation as it is an honest conductor of heat. As a result, the life of the brakes is increased, while the mileage is increased due to the lighter weight than others.

Mr.SumeetSatope [12] The energy conversion causes the speed to slow down and bring the vehicle into a steady state. Heat dissipation during driving has a significant impact on braking performance. High stress during operation can cause wear and discoloration. The performance parameters can be improved by considering the thermal properties of the disc brake material. The aim of this study was to investigate the thermochemical behavior of different brake discs under extreme operating conditions, to evaluate their efficiency and stability, and to identify their weaknesses. In this paper, a study is carried out by considering different materials used to manufacture brake discs and their thermal behavior in load state analysis of disc rotors of different shapes and different materials

Juraj Gerlici [13] For high-speed trains, the effectiveness of the braking system and the aerodynamic section modulus are looming when disc brakes are used for braking and result in reduced train traction. This paper discusses the possible causes of brake discs Aerodynamic loss level. The aerodynamic drag of various ventilated disc configurations as well as solid discs was evaluated. By analyzing the described measured and simulated data, the dependence of the aerodynamic losses on the rotational and linear velocity of the rolling stock is derived for different disc designs, namely radial vane, tangential vane, combined and solid disc. An example of calculating ventilation losses for different train sets.

Pietro Tooling[14] this study proposes two laser coatings to improve the wear resistance of cast iron brake discs. Wear resistance is assessed by pin-on-disk and ring-block laboratory testing. Commercial lining materials are used as counterparts in friction systems. Regular cast iron samples were used as reference material. During the test, the coefficient of friction is continuously recorded with sliding distance and the wear rate of the disc and pad material is calculated at the end of each test Laboratory-scale wear test results show that the proposed laser-plated SS coating containing WC particles is effective in improving the wear resistance of brake discs and linings compared to conventional uncoated GCIs. The wear rate of the R-SS layer is slightly higher than that of the HVOF layer, but the advantages can be achieved (according to the layer manufacturer) by a cost-effective deposition process and without the use of contaminants. In contrast, the wear properties of laser etched SS coatings are poor

Zhang Jian and Xia Changgao [15] This paper proposed that according to the real dimension of the braking disk, the finite element modeling for 3-d transient cyclic symmetry during the long downhill braking is established. The distribution of the transient temperature field of the rotor during the braking are analyzed. The variation of the friction factor combined with the temperature characteristics of the friction factor during the braking are analyzed. The analysis result shows that during the braking the the temperature of the brake rises increasingly and reaches the highest temperature of 316.04 degrees Celsius at the end of braking, the high temperature section concentrates in the far area of the rotor. The changes in the friction factor is relatively stable during the long downhill breaking and there is no obvious thermal recession. By the analysis of distribution of transient temperature field of brake disc under long downhill braking condition, it is obtained that the density of the heat flux increases with the increasing friction radius. Temperature gradient in the radial direction is higher. Thermal conduction and convection are enough. Temperature gradient in the axial direction is almost uniform

A.S.M. Ashique Mahmood [16] Topic modelling refers to statistical methods that analyse words in documents to discover latent semantic topics or themes. The most popular technique is latent Dirichlet allocation (LDA) which assumes each document contains a mixture of topics, and each topic is a distribution over words. LDA is an unsupervised, generative model that defines a process for randomly generating documents based on hidden topic structure. Extensions of LDA include dynamic topic models to track topic evolution over time, hierarchical LDA to model topic hierarchies, correlated topic models to capture topic correlations, and author topic models that associate topics with authors. Topic modelling has diverse applications like risk prediction in healthcare using clinical notes, drug repositioning based on drug labels, analysing gut microbiome samples, recognizing activities from sensor data, linking news to stock markets, and analyzing social media texts. Overall, topic modeling is a useful unsupervised technique to uncover thematic structure in text corpora across many domains.

G. Gilardi [17] This literature survey provides an overview of impact and contact dynamics modeling approaches, classified into impulse-momentum (discrete) models and continuous force-based models. Discrete models treat impact as an instantaneous event and use coefficients like restitution to account for energy loss. Continuous models explicitly model contact forces as a function of deformation to capture the continuous interaction. The paper reviews different restitution models for discrete approaches and contact force models like spring-dashpot and Hunt-Crossley models for continuous approaches. It also discusses experimental validation of these models and identification of parameters like restitution coefficient, contact stiffness and damping. Overall, continuous force-based models are better suited for complex contact scenarios between flexible bodies, while discrete models are limited by rigid body assumptions.

Khaled Teffah [18] This article presents a modeling and experimental study of a new thermoelectric cooler-thermoelectric generator (TEC-TEG) module. The module consists of a thermoelectric cooler (TEC) connected thermally in series with a thermoelectric generator (TEG), with a copper heatsink attached. The TEC cools its 18 cold side through the Peltier effect when a voltage is applied. The TEG acts as a partial heatsink for the TEC by converting some of the TEC's waste heat into electricity through the See beck effect. Finite element simulations in COMSOL Multiphysics and experiments were conducted to analyze the module's cooling capacity and power generation at different TEC input voltages. The results showed the cold side temperature decreased to 278.63K (simulation) and 287.3K (experiment) at 4V input. The TEG generated up to 0.5V open circuit voltage. This demonstrates the potential for a new cascade thermoelectric module for combined cooling and power generation.

S K Jha[19] The article discusses the importance of springs in various applications, such as car engines and valves. Springs are used to store and release energy, and they play a critical role in the proper functioning of many machines. The article reviews research that has been done to improve the performance of springs .One area of research is the use of composite materials, such as fiberglass, which are lighter and stronger than steel. Composite materials can be used to make springs that are lighter and more efficient. Another area of research is the use of computer simulation to design and test springs. Computer simulation can be used to predict the performance of a spring before it is actually built, which can save time and money. The article also discusses the importance of fatigue life. Fatigue life is the number of times a spring can be cycled (compressed and released) before it breaks. Springs are subjected to repeated stress in many applications, so it is important to choose a spring with a long fatigue life. The article reviews research that has been done to improve the fatigue life of springs. One area of research is the use of surface treatments, such as shot peening, which can strengthen the surface of a spring and make it more resistant to fatigue. Another area of research is the use of new materials, such as high-strength steels, which can withstand more stress before breaking.

G. Gilardi[20] The paper discusses different approaches to modeling contact dynamics, which is the study of how objects interact with each other when they come into contact. The two main approaches are discrete and continuous. Discrete methods use coefficients, such as the coefficient of restitution, to model the loss of energy during an impact. The coefficient of restitution is a number between 0 and 1 that represents the fraction of kinetic energy that is lost during an impact. For example, a coefficient of restitution of 0.5 would mean that half of the kinetic energy is lost during an impact. Continuous methods use forces to model the interaction between objects. These forces are calculated based on the geometry of the objects and the materials they are made of. Continuous methods are more accurate than discrete methods, but they can also be more complex to implement. The best approach for modeling contact dynamics depends on the specific needs of the application. If you need a simple model that is easy to implement, then a discrete method may be a good choice. If you need a more accurate model, then a continuous method may be a better choice.

Junye Ma [21] The article discusses different techniques for characterizing and reconstructing rough surfaces. The authors focus on two main categories of characterization: random field models and multiscale models. Random field models are based on the idea that the surface can be represented as a random function. Multiscale models, on the other hand, are based on the idea that the surface can be represented at different levels of detail. The article also compares different reconstruction methods, such as the MA-2D model and the fractal model. The MA-2D model is a simple model that is based on the idea that the surface can be represented as a sum of sinusoids. The fractal model is a more complex model that is based on the idea that the surface can be represented as a self-similar pattern. Overall, the article emphasizes the need for a more unified approach to surface modeling. The authors argue that current surface modeling techniques are often too specialized and that there is a need for a more general framework that can be used to model a wider range of surfaces.

Hanmanth [22] This article is about a liquid spring shock absorber designed for a defence application. The shock absorber is designed to isolate sensitive electronic equipment from shock loads. The article discusses the design and analysis of the shock absorber, as well as the mathematical modeling of the system. The shock absorber uses silicone oil as the working medium. The spring and damping characteristics of the shock absorber depend on the properties of the oil and the orifices. The governing equation of the liquid spring is a second order ordinary differential equation. The equation is solved using numerical integration to obtain the plots of displacement, velocity, and acceleration of the mass versus time.

Assad Abbas [23] The first paragraph of the article is about finite element analysis (FEA) in mechanical engineering. It discusses what FEA is and how it is used. FEA is a powerful tool that allows engineers to simulate and optimize mechanical systems. It is used in many different industries, such as aerospace, automotive, and bioengineering. : Finite Element Analysis (FEA) has emerged as a pivotal tool in modern mechanical engineering, enabling engineers to simulate and optimize complex systems with unparalleled accuracy and efficiency. This paper delves into the principles, methodologies, and applications of FEA within mechanical engineering. It explores how FEA facilitates virtual prototyping, structural analysis, heat transfer simulations, and optimization, revolutionizing the design and analysis of mechanical components and systems. By combining theoretical foundations with practical insights, this paper sheds light on FEA's role in shaping innovative solutions and driving advancements in the mechanical engineering landscape.

Katherine K. Fu [24] This article is about design principles. It discusses what they are and how they are used. The authors also explore different ways to research and develop them. They argue that design principles are important for solving complex problems. In the future, the authors hope that research on design principles will become more rigorous. The first paragraph of the article introduces the concept of design principles and their importance in solving complex problems. The second paragraph discusses different ways to research and develop design principles. The third paragraph argues that design principles are essential for effective design. The fourth paragraph concludes by calling for more rigorous research on design principles.

Dr. John Russell [25] The article presents a new methodology for analyzing the influence of a chassis on a vehicle's suspension and handling. The author builds two models, one rigid and one flexible, to investigate the effects of chassis torsional stiffness on load transfer. This methodology is intended to aid in the design of vehicles that consider these factors. The author begins by introducing the importance of chassis design in vehicle dynamics. A chassis' torsional stiffness, in particular, can significantly impact handling and suspension performance. Traditional methods for analyzing chassis effects are often time-consuming and computationally expensive. To address this challenge, the author proposes a new methodology that utilizes multi-body dynamics simulations. This methodology involves creating two models of the vehicle: one with a rigid chassis and one with a flexible chassis. By comparing the results of the two simulations, the author can isolate the effects of chassis torsional stiffness on load transfer. The author demonstrates the application of their methodology to a Formula SAE race car. The results show that chassis torsional stiffness has a significant impact on load transfer, particularly during cornering manoeuvres. The author concludes that their methodology can be a valuable tool for designing vehicles with optimal handling and suspension performance.

2. CONCLUSION

This article discusses disc brakes and the materials they are made from. It compares three different materials: cast iron, aluminium metal matrix composite, and mild steel. Finite element analysis is used to simulate the performance of disc brakes made from these materials. The results show that aluminium metal matrix composite is the best material for disc brakes .Here are some of the important points from the research papers mentioned in this article: Disc brakes are typically made of cast iron, but other materials like aluminium metal matrix composite and mild steel are also being explored Finite element analysis (FEA) is a computer aided design software used to analyze disc brakes Heat generation and dissipation are important factors to consider when designing disc brakes. The shape of the slots in disc brake rotors can affect their thermal conductivity. Different disc brake rotor designs can be optimized to improve heat dissipation. The material properties of disc brakes can also affect their performance. Finite element analysis can be used to analyze the thermoelastic behaviour of disc brakes.

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