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Review of Design and Thermal Analysis of Disc Brake Rotor

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ABSTRACT

The braking system is a critical component of every automotive. It is a mechanism for controlling the rotation of a wheel, the disc brake. Heat is generated during each braking event as a result of the vehicle's repeated braking. It is necessary to properly transport heat from the brake disc and pads, where kinetic and potential vehicle energy is transformed to thermal energy in the form of frictional heat during braking. It is possible for brakes to stop working if they grow too hot because they cannot disperse enough heat. Brake fade is the term for this type of failure. The disc brakes are subjected to substantial thermal loads during normal braking, as well as extreme thermal stresses during heavy braking. Disc brake rotor temperatures, heat flux distribution, and rotor behaviour in transient states were studied using a Finite Element Analysis technique. Transient thermal analysis of disc brake rotor and rotor designs is reviewed in this work for the purpose of evaluating and comparing their performance. Changing the rotor shape and material has been shown to enhance the heat transfer rate of disc brakes. That is the primary goal of this evaluation.

Keywords:Disc brake, Static Analysis, Thermal analysis, Total heat flux, direction heat flux, temperature.

1. Introduction:

In order to slow or stop the vehicle of an acceptable period of time, the braking system in a car is used. The brake system must be dependable in order to provide the driver of the vehicle more control. Kinetic energy may be found in every automobile because of its speed and mobility. Because kinetic energy is inversely related to speed squared, increasing the speed of a vehicle corresponds to an increase in its kinetic energy. Friction is the most common concept used in available braking systems to transform kinetic energy into thermal energy. Heat is released into the atmosphere as a result of this process. Disk brakes have become increasingly popular in light automobiles in recent years. Repetitive braking causes the temperature of the vehicle's brake components to increase, which diminishes the system's ability to operate. It's possible that the temperature of the brake fluid will rise, resulting in vaporisation of the brake fluid, if you're braking for a long period of time. In order to achieve optimum braking efficiency, the braking system must store and discharge all this heat into the surrounding environment. The following features should be included in the brake system. The brake disc's capacity to keep a steady temperature while transferring heat to the atmosphere improves the disc's performance.

1. The brakes must have strong anti-wear qualities.

2. In an emergency, within a set distance, the vehicle must be able to come to a full stop. The driver must maintain entire control of the vehicle while braking in order to prevent a skid.

3. There should be no degradation in stopping power with repeated, extended use of the brakes.

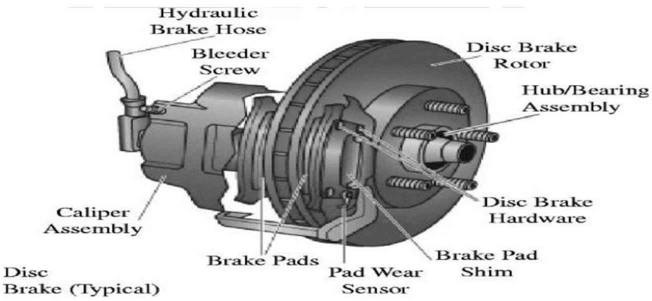

Figure 1: Disc brake

Using a set of callipers to apply pressure on brake pads against a brake disc, as seen in the figure above, slows the wheel's spin. The brake disc (or rotor in American English) is often made of cast iron, however composites such as reinforced carbon–carbon or ceramic matrix composites can also be utilised. Both the wheel and the axle appear to have a direct connection to this item. To control the rotation of the wheel, a device known as a brake calliper applies force to both sides of the disc via mechanical, hydraulic, pneumatic, or electromagnetic means. Due to friction, the disc and its corresponding wheel slow down or stop. It is called "brake fade" when brakes lose their stopping power due to reduced friction between the two surfaces that touch each other when they get very heated.

2. Literature Review

Manjunath et al [1]To help with disc rotor design and analysis, researchers examined the Transient Thermal and Structural Analysis of the Rotor-Disc in Disc Brake and evaluated the performance of a car's disc brake rotor during harsh driving circumstances. An ANSYS workbench 14.5 disc brake model and analysis were performed. Because they were interested in the thermomechanicalbehaviour of dry brake disc contact during the braking phase, they conducted their investigation with that goal at the forefront. In order to improve the rotor disc's performance, the deformation and Von Mises stress were determined using a combined thermal-structural study on both solid and vented discs made of two distinct materials.

Venkatramanan R et al [2] the temperature distribution of the rotor disc during operation was investigated and evaluated using Ansys. Disc brake material was studied in depth to better understand the friction and pressure forces that operate on it, in the hopes of reducing the number of accidents. By conducting heat transfer calculations between an existing disc and a hybrid disc, it was discovered that a copper liner lowers maximum temperature that can be attained by this disc.

A. Belhocine et al [3] with the thermal structural-coupled technique, numerical simulations were used consecutively to analyse the stress fields of disc deformations created by pad pressure. When compared to the results from the specialized literature, the simulation's outcomes are convincing.

Piotr Grześ [4] the purpose of this work was to examine the solid disc brake's thermal data during emergency braking. Disc brake heat analysis was carried out in this work. Parabolic heat conduction equations for two-dimensional models were employed in order to do the numerical simulation. Disc rotation speed and contact pressure were shown to be strongly correlated with certain material parameters in these studies.

RajendraPohane [5] The FEM model is now ready to be put through its paces with a contact analysis. Structure and transient analysis of the brake pad and disc are investigated using a 3D finite element model. The solid and vented discs are compared using general purpose finite element analysis with the same material attributes and restrictions. Disc-to-pad surface mechanical and thermal stresses may be analysed using general purpose finite element analysis tools.

HarshalNikam et al. [6] Moving vehicles are dynamically important, and their importance is depending on the mass and speed of the vehicles. Consequently, the vehicle's dynamic vitality is unable to be transformed into a warm significance by means of touch because of the moving back framework's limitations. Brakes are used to bring an automobile to a stop or pull it out of an emergency situation, and this vitality must be distributed. The Braking Torque Generated should be more than the Braking Torque Required when designing a vehicle's braking system. Because of the higher overall braking torque, a vehicle's tremendous spectra of power is tied together.

M. Nouby et al. [7]The sound of a circle-brake shriek is a confounding marvel. Continuous customer complaints and hefty guarantee costs have plagued automotive companies for a long time. Due to the high equipment costs of trial methods, the restricted component approach (FEM) has recently become the preferred option. Using the Standard restricted component programming, a rearranged plate brake model is examined. In order to determine a person's proclivity for screeching, the inquiry technique employs a nonlinear static recreation sequence followed by an astounding eigenvalue extraction. Scruech inclination is studied as a function of the key operating factors (braking weight and erosion coefficient). Changing the rigidity of the rotor and the rigidity of the rear plates under various job conditions is investigated. The results of this experiment show that the shrieking clamour may be reduced by increasing the rotor solidity and decreasing the backplate stiffness of the cushions.

K.Sowjanya, S.Suresh [8] Disk Brake is examined in this study. To put it another way, a "brake" is an apparatus that uses fake frictional opposition to halt a machine's movement. In studies on the influence of modest deviations from expected pressure circulations, the circle brake is often produced from a Cast press. Composite materials such as aluminium and metal are selected and disassembled. The results are compared to a plate rotor that is already in use. Solid showing programming in Pro/E is used to create the Disk brake model. ANSYS Workbench is used for further Static Analysis. To determine the Deflection, Normal Stress, and Vonmises pressure, a basic analysis is performed.

H Mazidi et al. [9] with the help of finite difference approach, he was able to tackle the heat conduction concerns of the disc brake components (Pad and Rotor). When solving time-dependent equations, the implicit technique is used. Derivation of heat equations includes consideration of factors such as braking time, vehicle speed and rotor and pad materials and contact pressure distribution.

Manjunath T Vet al. [10] during braking, the dry contact brake disc's thermo-mechanical behaviour was studied by researchers. Rotor disc performance is improved by determining the deformation and Von-Mises stress of the rotor discs using a combined thermal structural study on two separate materials. There is no discrepancy between analytical and FEM findings in terms of their accuracy. Based on the performance, strength, and stiffness criteria, the best possible design has been proposed.

Harish Mustiet al. [11] a thermal analysis of an improved disc brake rotor under harsh braking circumstances was carried out using Design and Analysis. Racing Cars employ disc brake rotors that have been improved in this research. Cast Iron, Aluminum, and Aluminum Composite are among the materials employed. There are no extrusions on the actual disc brake rotor. However, in our design, the brake rotor is better heat dissipated by putting alternative extrusions over it.

MansiRavalet al. [12] study of the maruti alto 800 disc brakes. Calculations of braking force and heat flux on the disc rotor of the alto 800 disc brake rotor design are produced using the specified parameters, making the disc brake design process clear.

S. R. Abhanget al. [13] I used (CCM) carbon ceramic matrix disc brake material to calculate normal force, shear force, and piston force. It may also be used to determine how far a disc brake can stop you.. Thermal and modal evaluations were done using Ansys to simulate the conventional disc brake on two-wheelers. Also calculated the disc brake model's deflection, heat flow, and temperature. Understanding the friction and action forces of a new disc brake material was easy.

Jimit G. Vyaset al. [14] Solid and cross-drilled disc brake rotors were designed and studied. Braking conditions were calculated using constants and assumptions. As a result of employing Ansys, it was determined that a thicker rotor will reduce conduction temperature decrease, and if the average braking cycle is short, using a solid disc brake is preferable, while cross-drilled disc brakes are better for longer cycles.

S. S Prasad [15] A drilled brake rotor investigation was conducted. The cross-drilled and uncross-drilled disc rotor types were designed. Cast iron, stainless steel, and aluminium alloys were among the materials explored for research. It was necessary to do additional structural and thermal studies on both of the aforementioned rotor types. Among the three, the aluminium ventilated disc was found to be the best option for the specified application.

P. N. Gunjalet al. [16]Ansys was used to do a thermal study on a simulated solid solid disc rotor with the specified dimensions. For optimal performance, a disc shape was adjusted based on the data received. Since shape-optimized disc brakes have less weight and mass than the one that was selected, they will save money.

P. N. Amrish [17] Disc brake rotors of the solid and drilled varieties, both ubiquitous in the automotive industry, were investigated and analysed in depth. In addition, he recommended a redesigned brake rotor design. Each brake rotor design was subjected to structural and steady state thermal study. Because the entire maximum stress exceeds the grey cast iron's ultimate stress limit, both solid and drilled rotors are structurally safe. A real-time car may use the rotor since its maximum total deformation is 0.00113 mm for solid rotors, and 0.000973 mm for drilled rotors. The drilled rotor's maximum temperature and total heat flux are somewhat lower because of the increased surface area for heat dissipation during braking owing to the drilled holes, but the temperature variation and heat flux are almost identical for both rotors.

N. Balasubramanyamet al. [18] Thermal elastic interaction with disc brake heat generation has been studied using finite element analysis. In order to investigate the thermo elastic phenomena occurring in disc brakes, the occupied heat conduction and elastic equations are solved using contact issues. Numerical studies of the thermoelasticbehaviour of disc brakes are accomplished in a repetitive braking scenario. It is possible to see how friction surfaces heat up and cool down in computer simulations. Flange width, Wall thickness, and material are suggested for disc brake rotors, according to the results.

D. Bhadgaonkaret al. [19] FEA was used to discover a flaw in a two-wheeler disc brake rotor using vibrational analysis. A modal analysis is also carried out in order to ascertain the inherent frequency of an existing disc in various mode shapes. There is a shift in the frequency curve when anything malfunctions, such as a disc brake crack. As the crack depth grows, so does the natural frequency of broken disc brake rotors.

V. Sushmaet al. [20] a two-wheeler disc brake with a square groove and a circular groove was thermally and structurally analysed Stability and stiffness were examined for the purpose here, and the ideal settings for disc brake rotors were proposed. Examined are the effects of various geometric forms, including those with and without grooves, squares, and circles. According to the study, a disc brake with a 2mm square form and Gray Cast Iron material is the optimum option for this particular application.

3.Conclusion

Ideally, our car's braking system should be able to provide smooth, noise-free braking under a variety of road and temperature circumstances. During our everyday commute, we don't want to deal with the nuisance of a noisy and dusty brake. Brake friction materials have developed greatly over the years to satisfy these requirements. In the past, they used asbestos, but now they use organic and semi-metal compositions. The environmental friendliness, wear, noise, and stopping power of each of these materials have been found to vary widely. Having durable and efficient braking system is a need of any automobile. This is achieved through constant improvement and enhancement in brake rotor design and geometry. There is scope of improvement in heat transfer by providing vanes between two rotors for considering above mentioned rotor geometry, considering different materials so as to ascertain the best material.

References

[1] Manjunath T V, Dr Suresh P M, “Structural and Thermal Analysis of Rotor Disc of Disc Brake”. International Journal of Innovative Research in Science, Engineering and Technology. Vol. 2, Issue 12, December 2013.

[2] Venkatramanan R, Kumaragurubaran Sb, SubramaniyanSivakumar, SaravananBoobalan, “Design and Analysis of Disc Brake Rotor”. ICAETSD 2015.

[3] Ali Belhocine “THERMOMECHANICAL STRESS ANALYSIS OF VEHICLES GRAY CAST BRAKE”, Research Gate January 2015.

[4] Piotr Grześ “Design, analysis and optimization of brake disc made of composite material for a motorcycle”,

International Journal of Research Publications.

[5] RajendraPohane, R.G.Choudhari, 2011 “Design and Analysis of Disc Brake Rotor”, International Journal of Applied Engineering Research ISSN 0973-4562 Volume 10, Number 19.

[6] Harshalnikamet. al., "Design and Analysis of Brake Rotor with Parameter Optimization", International Journal of Automobile Engineering Research and Development (ijauerd) ISSN(P): 2277-4785; ISSN(E): 22789413 Vol. 4, Issue 4, Aug 2014, 21-30

[7] VirajVijaykumarShinde ,ChetanDhondiramSagar , Baskar P. "Thermal and Structural Analysis of Disc Brake for Different Cut Patterns", International Journal of Engineering.

[8] Swapnil R. Abhang, D.P.Bhaskar, “Design and Analysis of Disc Brake” International Journal of Engineering Trends and Technology (IJETT) – Vol. 8,Issue 4, PP. 63- 70,Feb 2014.

[9] A. Belhocinea, C.-D. Chob , M. Noubyc , Y. B. Yid, A. R. Abu Bakare, “Thermal analysis of both ventilated and full disc brake rotors with frictional heat generation” Applied and Computational Mechanics –Vol. 8, Issue 02, PP. 5-24, 2014.

[10] P. N. Gunjal, Hredeya Mishra, “Design, Analysis &Optimization of Disk Brake”. IJARIIE-Vol. 1, Issue 5, PP 335-340, 2015.

[11] Pandya NakulAmrish, “Computer Aided Design and Analysis of Disc Brake Rotors”. Advances in Automobile Engineering-Vol. 5, Issue 2, PP. 1-13, 2016.

[12] MansiRaval, Prof. Mit Patel, Jenish Patel “Design of Disc Brake’s Rotor”,IJEDR – Vol. 4, Issue 4, PP. 919-926,2016.

[13] Manjunath T V, Dr. Suresh P M “Structural and Thermal Analysis of Rotor Disc of Disc Brake”, International Journal of Innovative Research in Science, Engineering and Technology (ILIRSET) -Vol. 2, Issue 12, PP. 7741- 7749, December 2013.

[14] Harish Musti, DR.K.Sudhakar Reddy, “Enhancement in design and thermal analysis of disc brake rotor” international journal of engineering sciences & research technology- Vol. 6, Issue 2, PP. 498-505, February, 2017.

[15] H Mazidi., Jalalifar S., Jalalifar S., Chakhoo J., “Mathematical modeling of heat conduction in a disk brake system during braking”, Asian Journal of Applied Sciences- Vol. 4, Issue 2, PP. 119-136, 2011.

[16] N. Balasubramanyam, G. Prasanthi, “Design and Analysis of Disc Brake Rotor for a Two Wheeler”. International Journal of Mechanical and Industrial Technology (IJMIT) - Vol. 1, Issue 1, PP 7-12, 2014. [17] D. Bhadgaonkar, A. Singh, “Vibrational Analysis of Disc Brake Rotor of a Two Wheeler to find the defect using FEA”. IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE) - Vol. 3, Issue 1, PP 01-06, March 2017.

[18] V.Sushma, P. Ravinder Reddy, “Thermal and Structural Analysis of Disc Brake with Square / Circular Groove for Two Wheeler”. International Advanced Research Journal in Science, Engineering and Technology- Vol. 2, Issue 7, PP 74-79, July 2015.

[19] RajendraPohane R.G., Choudhari, “Design and Finite Element Analysis of Disc Brake”, International Journal of Engg. Research &Indu. Appls. (IJERIA)-Vol. 4, Issue 1, PP. 147-158, 2011.

[20] http://en.wikipedia.org/wiki/Disc_brake