DESIGN OPTIMIZATION OF DISC BRAKE BYUSING FINITE ELEMENT ANALYSIS

[1]SOURAV RANJAN SAHU,

Gandhi Institute of Excellent Technocrats, Bhubaneswar, India

[2]TUSHAR RANJAN SAHOO,

Eastern Academy of Science and Technology ,Bhubaneswar, Odisha, India

ABSTRACT:

The brake is a mechanical device that is attached to the moving engine components and reflects the friction protection to keep the engine running. The brakes collect the kinetic energy of the moving area and the potential energy lost as a result of the lift and other means of lowering the object at this point. The brakes both absorb and disperse energy. Disc brakes are a common vehicle component found in both vehicles and bicycle wheels. A brake catches the caliper disc, which is attached to two pads on the stud shaft powered by the cylinder. When the brake lever is pressed, the hydraulic fluid is injected into the chambers, allowing the opposite cylinders and brake pads to make frictional contact with the disc. Frictional heat during braking causes brake failure, initial wear, thermal breakage, and disc thickness changes (DTV). Pre-defined element studies of disc brake thermal analysis rarely combine surface roughness and pad contact wear. The main objective of this study is to improve the vehicle brake discs and to examine the static-level thermal behaviour of the dry contact between the brake disc and the brake pads during braking. Disc decay and van der Waals pressure were calculated using thermo-structural analysis. The project aims to design, analyse, and upgrade solid and ventilated disc brakes using SolidWorks, Hyper Mesh, and ANSYS. When tightening the vent brake disc assembly, the straps are pressed and placed on the ANSYS to assess the pressure fields and deformations.

KEYWORDS: ***BRAKE; MECHANICAL DEVICE; KINETIC ENERGY; THICKNESS VARIATION***

1. Introduction

A brake is a mechanical device that uses friction to convert the speed or kinetic energy of a moving vehicle into heat. When needed, park the car or get out as soon as possible. On the road surface and in the centre of the tires, the steady operation of the vehicle's brakes is clearly visible. The kinetic energy related to the speed of the vehicle is released as thermal energy as a result of the interaction between the moving parts (wheel or wheel drum) and the fixed parts of the vehicle (brake shoes). Breaking energises thermal energy, which is dishwasher in the circulating air.

Fixed-caliper disc brakes and floating-caliper disc brakes are two types of disc brakes. A conventional caliper is made up of two or more pistons that act immediately on the inner and outer pads. To increase the braking power, two or more pistons may be used. As each piston travels with equal pressure, the pistons attempt to halt the revolving disc by putting equal pressure on both sides of the rotor. The fundamental drawback of the typical caliper is that it necessitates a rotor space that does not correspond to the geometric specifications of current front suspensions. All car braking systems now employ a floating caliper. On its mounting pins, the caliper is free to float sideways. The piston is pushed forward when the hydraulic line pressure is applied, and the caliper is forced into the outer pad disc when the inner pad disc is pressed. By pushing the pad against the rotor, the hydraulic pressure is converted into force. The required brake friction forces are generated as a result.

Figure 1.A fixed rotor and a floating caliper-piston assembly that rotates with the vehicle's wheel through the driving axles in which the piston slides on the caliper and is attached to the vehicle's anchor bracket. A suspension system and a set of brake pads are included. Surface hardness and pad contact wear were rarely considered in previous thermal analysis of disc brakes research using the finite element method. The main purpose of this research is to build an automotive brake disc and explore the static thermal behaviour of the dry contact between the disc and the pads during braking. Disc degradation and Von Misses stresses were calculated using thermo-structural analysis. The project is to develop, analyse, and improve solid and vented

disc brakes using SolidWorks, Hyper Mesh, and ANSYS.

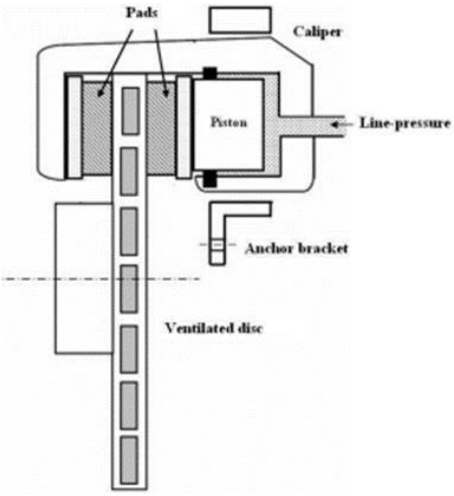

Figure 1. Floating disc brake components

2. METHODOLOGY

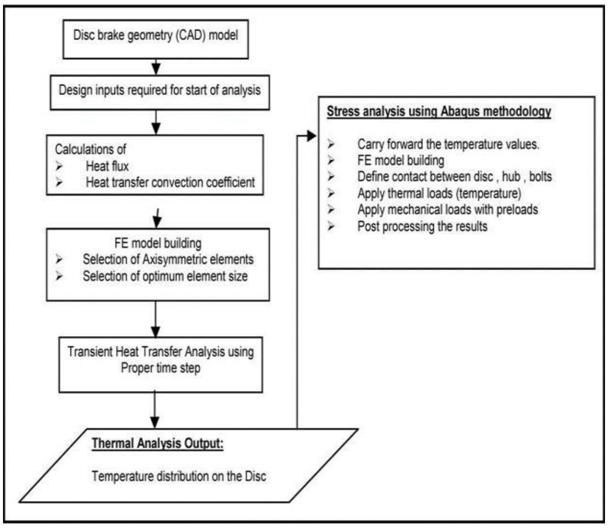

Figure 2. METHODOLOGY

There are various reasons for disc thickness variation, but three main factors contribute to disc thickness variation. The first brake pads were a poor choice. The straps, which operate effectively at low temperatures, are usually made of materials that randomly deteriorate at high temperatures when broken early in cold weather. Uneven material deposition occurs on the brakedisc as a result of random deformation. Insufficient pad/disc disintegration might also result in random material transfer. The disc surface must be restored when the pads are replaced in order to maintain proper spacing (either by milling the contact surface or by replacing the disc). Brakes are applied on a frequent basis for brief durations of time. As a result, the contact between the pad and the disc is uniform and smooth. If this is done wrong, the brake pads will be subjected to an uneven distribution of pressure and heat, resulting in a disruptive, uneven pad material precipitation. The third and last step of random bat material transfer is "bad imprinting." When the brake pads heat up, the material distorts and moves to the disc, causing this transfer. This transfer is prevalent in well-broken brake systems (with well-selected pads) and contributes significantly to the brake pads' braking force. This transfer is normal in a well-broken brake system (with well-selected pads) and greatly increases the braking force supplied bythe brake pads. The straps will stack one-layer high in the form of the brake pad if the automobile is fully parked and the driver repeatedly uses the brakes. This modest thickness change can be used to modify the rotation of the random pad transfer. This transfer is normal in a well-broken brake system (with well-selected pads) and greatly increases the braking force supplied by the brake pads. If the car is fully parked and the driver constantly applies the brakes, the straps will stack one-layer high in the shapeof the brake pad. This modest thickness change can be used to modify the rotation of the random pad transfer. The straps willstack one-layer high in the form of the brake pad if the automobile is fully parked and the driver repeatedly uses the brakes. This modest thickness change can be used to modify the rotation of the random pad transfer. With variations in disc thickness, random pad deposition can accelerate, causing changes in the crystal structure of the disk-forming metal. The straps glide over different disc surfaces when the brakes are engaged. The straps are adjusted from the exterior as they go through the thicker area of the disc. The driver's foot instinctively opposes this shift, providing extra power to the brake pads. As a result, stress is increased in thicker areas. As a result, the disc surface warms up evenly, causing two major problems. The brake disc expands uniformly as it heats up. The thicker areas of the disc expand more than the thinner parts as a result of the heat, increasing the thickness imbalance. Furthermore, heat distribution is uneven, resulting in unexpected pad material transfer. As a result, thick-heatedregions of the disc receive more pad material than thin-cooled portions, causing the thickness of the disc to vary significantly. Random heat can ruin the crystal structure of the disc material at extreme conditions. The metal undergoes a phase change when heated regions of the discs reach very high temperatures (1,200–1,300 F or 649–704 C), and the carbon leaves the carbon glaze, leaving carbon-heavy carbon. Take, for example, Cementite. As a result, thick-heated portions get more pad material than thin- cooled ones, causing the disc's thickness to fluctuate more. Under high conditions, random heat can destroy the crystal structure of the disc material. When the heated sections of the discs reach very high temperatures (1,200–1,300 F or 649–704 C) and thecarbon glaze exits, the metal undergoes a phase transition, resulting in carbon-heavy carbon. This iron carbide, like cementite, is significantly distinct from the rest of the disc-forming cast iron. Despite the fact that the disc surface is mechanised, the cementite in the disc does not absorb or absorb heat at the same pace as the cast iron around it, causing the disc to resurface with irregular thickness and heating capabilities.

3. Design Problems

Due to the random expansion rate of the disc under extreme duty conditions, minor bone fractures may appear at the margins of the holes punched in the disc's edge, resulting in small cracks in the edges of the holes drilled in the disc's edge. Perforated discs are used by OEMs for one of two reasons: origin or engineering. They think the brake disc has the mass to withstand the heat and pressure of a race while also decreasing the brake unit's juvenile weight. Despite the fact that the brake disc is a heat sink, the large surface friction for heat dispersion compensates for the whole loss. In the worst-case scenario, little hairline cracks on a cross-drilled metal disc might appear spontaneously as a result of wear. They have the potential to cause catastrophic devastation in the worst-case scenario. If the fractures are both irreparable and significant, the disc should be replaced. These cracks are caused by low rotational fatigue, causing significant braking. Corrosion on the surface of cast iron discs is common. Regular use will maintain the brake pads' disc contact area clean, but if the vehicle is parked for an extended length of time, there may be significant rust in the contact area, which may reduce braking efficiency for a while until the rusty finish wears off. Because to differences in heat and storage between the stainless steel components covered by the straps, when the brakes are re-activated after storage, the rust disc will bend over the bulk of the surface area. Due to differences in heat and storage between the stainless steel components covered by the straps, when the brakes are re-activated after storage, the rust disc will bend over the bulk of the surface area. Separate hydraulic circuits are used to operate the brakes on each wheel in modern autos as a safety feature.

Furthermore, the hydraulic system aids in increasing braking force. The number of "pots" in the invitation corresponds to the number of pistons. As a consequence, each caller saves six pistons in a car with "six pot" calipers. The most common type of calliper is a single hydraulically powered piston inside a cylinder, while high-performance brakes can have up to twelve. As a safety measure, modern vehicles employ separate hydraulic circuits to activate the brakes on each wheel. Furthermore, the hydraulic system aids in increasing braking force. The number of "pots" in the invitation corresponds to the number of pistons. As a consequence, each caller saves six pistons in a car with "six pot" calipers. Variations in disc thickness or unanticipated wear patterns cause this (DTV). The use of heavier automobiles on the road, on the other hand, commonly causes cold judder faults on the disc surface. DTV can be caused by a variety of factors, including disc surface ripple and roughness, print misalignment (runout), corrosion, abrasion, and abrasive substance transfer. Make sure the mounting area between the wheel hub and the brake disc hub is clean before utilising the brake disc. This may be accomplished in a number of ways, such as concentrating on printing after each usage and completely depressing the brake pedal. Cleaning and lowering the bed are both required phases in the procedure. Braking fading is a condition that causes brake performance to deteriorate. This diminishes braking power and provides the impression that the automobile was not started with the brakes on. The heat created by the brake pads is the reason behind this. Gaseous compounds generated by the heated brake pads fill the space between the disc and the brake pads. The contact between the brake pads and the disc is diminished as a result of these gases, lowering braking effectiveness.

4. Design

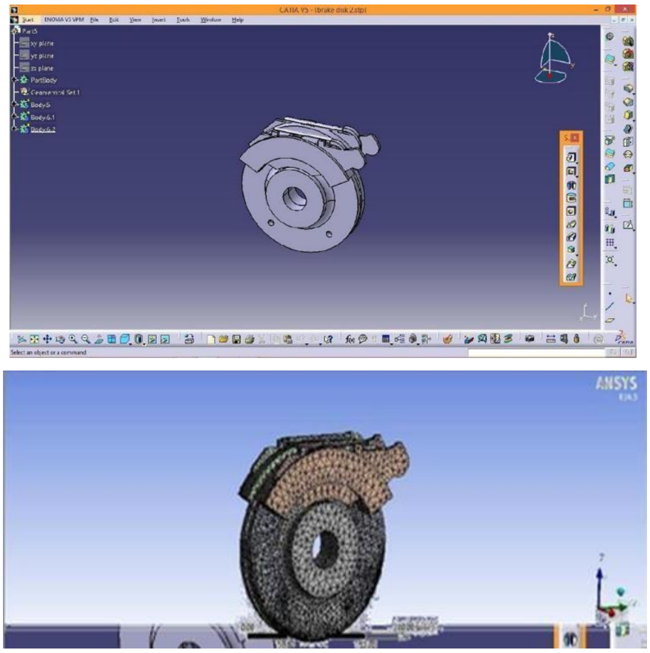

Figure 3: DISC BRAKE

5. Analysis

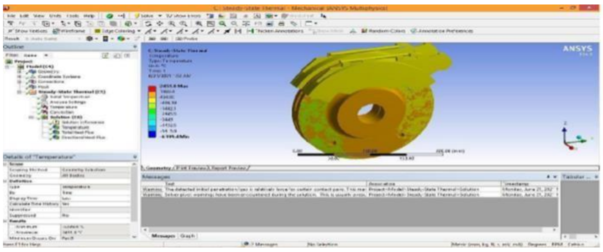

Figure 4: STEADY THERMAL ANALYSIS

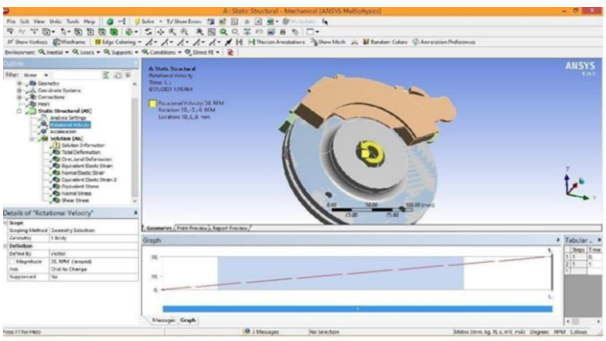

Figure 5: BOUNDARY CONDITION

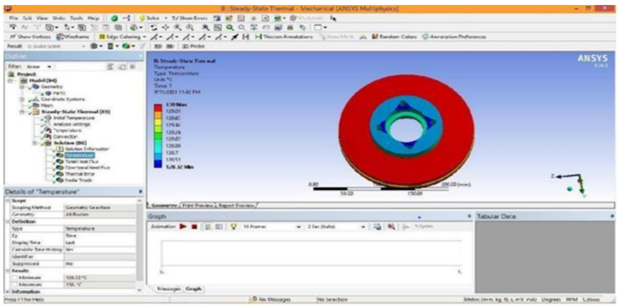

Figure 6: THERMAL ANALYSIS

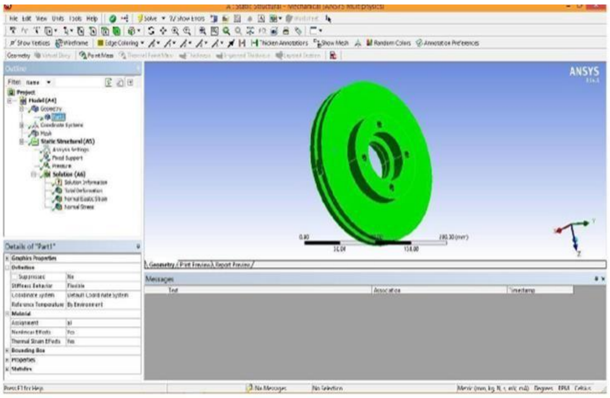

Figure 6: PROPOSED MATERIAL-AL Result Tabulation

6. Result Tabulation

S.NO	PARTICLES	AL	TI	ZI	STEEL
1	TOTAL DEFORMATION	9.1669*E-10	9.43*E-10	9.7281*E-10	10.1*E-10
2	NORMAL ELASTIC STRAIN	1.8118*E-12	1.86*E-12	0.19228*E-12	-
3	NORMAL STRESS	6.52*E-6	6.52*E-6	6.528*E-6	-
4	TEMPERATURE	129.85	129.85	129.87	129.81
5	TOTAL HEAT FLUX	0.004006	0.0040063	0.0040103	0.003998
6	DIRECTIONAL HEAT FLUX	0.0020742	0.0020742	0.0020743	0.0020741
7	THERMAL ERROR	84.855	84.855	75.008	105.66

7. Conclusion

This article shows how to use Solid Works to create straight and vented brake discs . The hyper mesh, a temperature-related component, is also included. Finally, two brake discs were subjected to continuous thermal examination at Ansys. Converting straight brake disc vents to curved vents decreases van mis pressure, displacement vector size, and brake disc mass, according to these experiments. Straight air brake discs have a lower heat transfer rate than curved vent discs.

REFERENCES:

[1] . Finite Element Analysis for Engineering &Tech. Author, T.Chandraputla. Edition, illustrated. Publisher, Universities Press,2004.ISBN, 8173714274 Machine Design Edition: 14th. Author:

[2] R.S. Khurmi& J.K. Gupta Chengal Reddy, M. Gunasekhar Reddy, Dr. G. HarinathGowd “Modeling And Analysis of FSAE Car Disc Brake Using FEM” International Journal of Emerging Technology and Advanced Engineering, ISSN 2250-2459, ISO 9001:2008 Certified Journal, Volume 3, Issue 9, September 2013.

[3] Manjunath T V, Dr Suresh P M “Structural and Thermal Analysis of Rotor Disc of Disc Brake” An ISO 3297: 2007 Certified Organization, Vol. 2, Issue 8, August 2013

[4] Ameer FareedBasha Shaik1, Ch.LakshmiSrinivas., “Structural and Thermal Analysis of Disc Brake with and without cross drilled rotor of race car”, International Journal of Advanced Engineering Research and Studies, Vol. I/ Issue IV/July- Sept.,2012/39-43, India. AliBelhocine, MostefaBouchetara. Thermal analysis of a solid brake disc, Applied Thermal Engineering 32 (2012) 59-67.

[5] Guru Murthy Nathil, T N Charyulu, “Coupled Structural/ Thermal Analysis of Disc Brake” IJRET, Vol.2,

PP 539-553, 2012.

[6] Jiguang Chen, Fei Gao (2014), Thermo-Mechanical Simulation of Brake Disc Frictional Character by Moment of Inertia, Research Journal of Applied Science Engineering and Technology 7(2), 227-232.

[7] M. Collignon, L.Cristol, P.Dufrenoy, Y.Desplanques, D.Balloy (2013), "Failure of truck brake discs: A coupled numerical– experimental approach to identifying critical thermomechanical loadings, Tribology International 59, 114 –120.

[8] Pier Francesco Gotowicki, Vinzenco Nigrelli, Gabriele Virzi Mariotti, Dr. Cedomir Duboka (2005), Numerical and Experimental Analysis of a Pegs-Wing Ventilated Disk Brake Rotor, With Pads and Cylinders, 10th EAEC European Automotive Congress. \

[9] Adam Adamowicz, Piotr Grzes (2011), Analyzed disc brake temperature distribution during single braking under nonaxissymmetric load, Applied Thermal Engineering 31, 1003-1012. O.P. Singh et al (2010), Thermal seizures in automotive drum brakes, Engineering Failure Analysis 17, 1155–1172.

[10] S Naveen Kumar et al (2012) Redesign of Disc Brake Assembly with Lighter Material, International Journal of Engineering Research & Technology (IJERT), ISSN: 2278- 0181, Vol. 1 Issue 7.

[11] Daniel Das.A et al (2013), Structural and Thermal Analysis of Disc Brake in Automobiles, International Journal of Latest Trends in Engineering and Technology (IJLTET), ISSN: 2278-621X, Vol. 2 Issue 3.

[12] D. Murali Mohan Rao, Dr. C. Prasad, T.Ramakrishna (2013), Experimental and Simulated Studies on Temperature Distribution for Various Disc Brakes, International Journal of Research in Mechanical Engineering & Technology (IJRMET) Vol. 3, Issue 1, ISSN : 2249-5762 (Online) | ISSN : 2249-5770 (Print), Nov - April.

[13] G. Babukanth and M. Vimal Teja "Transient Analysis of Disk Brake by using Ansys Software" International Journal of Mechanical and Industrial Engineering (IJMIE), ISSN No. 2231 –6477, Vol-2, Issue-1, 2012.

[14] Oder, G., Reibenschuh, M., Lerher, T., Sraml, M.; Samec, B.; Potrc, I. "Thermal and Stress Analysis Of Brake Discs In Railway Vehicles" at International Journal of Advanced Engineering 3(2009)1, ISSN 1846-5900.

[15] Daniel Das.A, Christo Reegan Raj.V, Preethy.S, Ramya Bharani.G "Structural and Thermal Analysis of Disc Brake in Automobiles" at International Journal of Latest Trends in Engineering and Technology (IJLTET) ISSN: 2278-621X Vol. 2 Issue 3 May 2013.