

A SURVEY PAPER ON THERMAL ANALYSIS ON BRAKE ROTOR DISC

Ashish Ranjan Bhagwat¹, Second Author Prof. Sohail Bux²

¹PG, Scholar, Dept. of Mechanical Engineering, AGNOS College of Technology, Bhopal, MP, India

²Professor, Dept. of Mechanical Engineering, AGNOS College of Technology, Bhopal, MP, India

¹ashishpcst3@gmail.com

²buxsohail@gmail.com

Abstract - The disc brake is a mechanism that used for reducing speed or discontinuing the cycle of the vehicle. many times using the brake for vehicle starts to heat producing during braking process, such that disc brake undergoes breakage due to high Temperature. Hence best appropriate design, low thermal gradient material cast iron is chosen for the Disc Brakes for better result find out and numerical methods and analysis procedures used in the study of automotive disc brake. It covers Finite element Method approaches in the automotive industry, the complex Contact analysis. The advantages and limitations of each approach will examine. This review can help analysts to choose right methods and make decisions on new areas of method development. It points out some outstanding issues in modeling and analysis of disc brake squeal and proposes new conceptual design of the disk braking system. It is found that the complex Contact analysis is still the approach favored by the automotive industry. Analysis of brake rotor includes Structural analysis and Steady state Thermal analysis for each design..This paper reviews work of previous investigators on Structure and transient analysis on the vented disk rotor and rotor designs to evaluate and compare their performance.

Keywords — Structure Analysis, Disc, FEM, Braking System, Automotive Industry

I. INTRODUCTION

Brakes are compulsory safety components used in all modern vehicles. Brakes are used to slow a vehicle down or used to bring a vehicle to a halt. These components function to slow and stop the rotation of a wheel bringing the speed of the vehicle down. This task is completed where by the braking pads are forced mechanically against the rotor disc on both surfaces of the wheel allowing the vehicle to slow down. [1] There are different types of brake systems such as disc brakes which use a friction system in which brake pads are mechanically forced against the rotor disc with a set of calipers. Drum brakes are also used on friction systems where a set of pads are pressed against the brake drum allowing the vehicle to slow down. [1]. These brakes offer better stopping performance than comparable drum

brakes, including resistance to "brake fade" caused by the overheating of brake components, and are able to recover quickly from immersion (wet brakes are less effective). Discs have now become the more common form in most passenger vehicles, although many (particularly light weight vehicles) use drum brakes on the rear wheels to keep costs and weight down as well as to simplify the provisions for a parking brake. As the front brakes perform most of the braking effort, this can be a reasonable compromise.

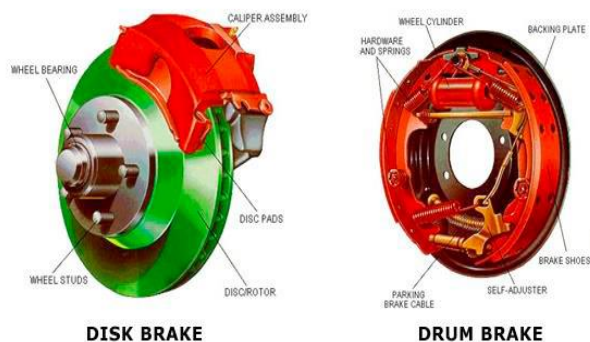


Figure.1 Car Rotor disc

Friction brakes act by generating frictional forces as two or more surfaces rub against another. The stopping power or capacity of a friction brake depends on the area in contact and coefficient of friction of the working surfaces as well as on the actuation pressure applied. Wear occurs on the working surfaces, and the durability of a given brake (or service life between maintenance) depends on the type of friction material used for the replaceable surfaces of the brake. If brake disc are in solid body the Heat transfer rate is low. Time taken for cooling the disc is low. If brake disc are in solid body, the area of contact between Disc and Pads are more, so efficiency of brake is high. We introduced variation in vanes pattern on the disc in ventilated disc brake. The Heat transfer rate is increase. Time taken for cooling the disc is high. It has been seen that the generation of huge amount of temperature on disc surface during braking needed to be dissipated as efficiently and soon as possible.

It's observed that many factors are responsible which restricts heat dissipation, ultimately leading to brake failure due to situation like brake fade and judder. Factors such as Vehicle speed, type of braking (Emergency braking or repetitive braking), rotor geometry and dimension, disc or pad materials (Cast iron, Aluminium metal matrix composite, ceramics etc), contact pressure distribution etc are some certain factors which can be varied to achieve a satisfactory heat dispersion.

II. LITERATURE REVIEW

All paragraphs must be indented. All paragraphs must be justified, i.e. both left-justified and right-justified.

Praharsha Gurram et. al . [2019] Brakes are one of the most essential security structures in a vehicle. In the hindering methodology, the rotor will be introduced to huge weights which achieve surface breaking, overheating of brake fluid, seals and various parts. Thusly one of the rule tasks of the halting system is to diminish the surface temperature of the brake rotor. This can be practiced by picking the right material which will encounter the least warm weights. In this paper a point by point examination of essential, warm assessment for vented with cross-entered holes circle brake rotor of Audi A6 is done, for giving a capable material to plate brake rotor which can dissipate heat made during easing back down at snappier rate and moreover being fundamentally secured, like Gray cast iron, Stainless steel, Aluminum silicon carbide MMC, carbon terminated grid, E-Glass fiber, Titanium blend, Aluminum compound, Aluminum metal framework composite. The results obtained are watched and separated for optimization.[1]

A. Naga Phaneendra et. al [2018] The work deals with the examination of warmth age and dispersing in a solid hover brake of a cruiser during constant easing back somewhere around using PC - helped structuring programming with two plate profile and three one of a kind materials of the rotor plate. The objective of this work is to investigate and look at the temperature movement and warmth dispersal (predictable state warm examination) of the rotor plate during hindering action. The work uses the restricted segment assessment methodology to foresee the temperature flow on the plate rotor and to perceive the essential temperature of the brake rotor circle. All of the three techniques for warmth move (conduction, convection, radiation) have been explored. The three novel materials considered are Gray Cast Iron, Aluminum Alloy 6262 T-9 and Carbon-Ceramics with two particular profiles of plate rotor. The results obtained from the assessment shows that assorted material on tantamount weight conditions during constant hindering shows particular temperature dissemination. Thusly, a connection is made between the three materials used to know the best material for making circle brake rotor subject to the pace of warmth dispersing and essential temperature. Along these lines,

it is found that Aluminum Alloy is the most appropriate material among all of the three material decided for solid plate rotor.[2]

Pravin Mohan et. al [2017] The going with work ponders a sensible arrangement of a plate halting system. Plate brakes offer better easing back down, less troublesome structure, lighter weight, and favored security from water impedance over drum brakes. The purpose of this applied arrangement was to assemble the nature of the caliper, without growing the greatness of the caliper by a gigantic whole and decreasing the warm bending at high working temperatures. Since titanium is difficult to machine the mono square structure of customary machined caliper was not used in this work yet an undertaking was made to produce a brake caliper with different parts and assembled to make a lone unit. Also titanium parts used were machined from plates with no tangled shapes to get a good deal on machining costs in future. Since titanium has higher mass thickness care was taken while organizing the new halting system to keep the weight addition to least. The current brake caliper was dismembered for given weight conditions with new material suggested. The results were perused for movements and stresses close by warm effects. The new specific caliper was inspected for pressure and unessential weight sand the results were perused for migrations/contortion and stresses with temperature impacts. [3]

S. Arvin Rao, et. al [2017] Brakes shriek has remained to be one of the critical Noise, Vibration and Harshness (NSH) challenges in halting system plan and improvement. It has been a concern for vehicle industry for decade. Brake experts have proposed many brake shriek reduction and neutralization procedures to endure and lessen the shriek that radiates from the brake plate structures. In this paper, the suitability of obliged layer dampers (CLD) in reducing circle brake shriek upheaval was analyzed. CLD disconnects the brake shriek uproar through shear distortions of the viscoelastic materials. Two plans of brake tests were coordinated using the brake test dynamometer with the utilization of CLD. Two particular kinds of CLD were used which are three-layer obliged layer damper and four-layer constrained layer damper. Shriek tests were finished using brake upheaval test rig reliant on the overall standard technique SAE J2521. From the test, four-layer CLD configuration works more successful than three-layer CLD course of action. CLD included nitrile butadiene flexible, silicone versatile and delicate steel wind up being the best uproar defender at water fueled weight extent of 5 bar to 30 bar and temperature extent of 50oC to 200oC with a most extraordinary fuss reduction of 11.3 dBA. As needs be, CLD methodology was exhibited to be a convincing procedure in lessening brake shriek noise.[4]

Yugesh Anil Kharche et al [2014] The plate brake is a device for decelerating or ending the turn of a wheel. Easing back down is a method which changes over the dynamic imperativeness of the vehicle into mechanical essentialness which must be scattered as warmth. This paper presents the assessment of the contact pressure scatterings at the circle interfaces using a clear 3-dimensional restricted part model of a certified vehicle plate brake. Constrained part (FE) models of the brake-plate are made using Pro-E and reproduced using ANSYS which relies upon the restricted segment procedure (FEM). It is also explores different levels in showing a plate halting system and emulating contact pressure flows at various weight. It covers Finite Element Method approaches in the vehicle business the Contact assessment and warm examination. The effect of the saucy speed and the contact pressure movement on temperature climb of plate brake was investigated. Wear in contact material infers that diminishing of its future. The more the wear, the sooner the frictional material ought to be superseded. Various Brake pad material is attempted as differentiated and the current one. Finally assessment between efficient results and result procured from Ansys finished, and all the characteristics got from the examination are not actually their allowable characteristics. Subsequently dependent on warm and contact pressure assessment best sensible material is suggested.[5]

K. M. Muniswamy et al. [2013] Heat move enhancement for ventilated brake plate with bleeding edge propensity edge assortment. The objective of the current assessment is to investigate the potential warmth move updates in ventilated brake hover by moving the geometrical limits of the edges inside the stream segment. The thickness remains consistent and simply the length can be changed to fit the inward and outer range. The computational model created in GAMBIT. The models are clarified using ANSYS-FLUENT prohibitive programming pack. The results show a gigantic addition in the glow move rate with front line inclination edge structures when appeared differently in relation to customary straight edge. The Nusselt number is viewed as in a power law relationship with the Reynolds number. Specific association among laminar and stormy condition is envisioned. [6]

K. Sowjanya&S.Suresh [2013] Presented paper on Structural examination of plate brake rotor. Circle brake is ordinarily made of Cast iron, so it is being picked for exploring the effect of solidarity minor takeoff from the foreseen pressure transports. Aluminum Metal Matrix Composite materials are picked and examined. The zone is considered as center symmetric, inaction and body power impacts are insignificant during the assessment. The model of Disk brake is made by using Solid exhibiting programming Pro/E (Cero-Parametric 1.0).Further Static Analysis is done by using ANSYS Workbench. Warm response for the helper assessment and the most extraordinary Von Misses pressure

supposedly was 50.334 M Pa for CI, 211.98 M Pa for AIMMC1, and 566.7 M Pa for AIMMC2, the Brake plate arrangement is shielded subject to the Strength and Rigidity Criteria[7]

Zhang Jiang& Xia Changgao [2012] Research of the transient temperature field and scouring properties on circle brakes. The 3D transient and cyclic uniformity restricted segment model of the temperature field of the ventilation caliper hover brake in a long downhill hindering condition was developed in this paper. The restricted part showing for three-dimensional transient cyclic equality during the long downhill easing back down is set up. The assortment of the grinding component got together with the temperature characteristics of the scouring factor during the easing back down are inspected. Examination is done by using constrained segment programming ANSYS. During the easing back down, the temperature of the brake rises logically and shows up at the top temperature of 316.04°C close to the completion of hindering technique; the high temperature fragment packs in the most far off zone of the grinding surface. The most extraordinary pace of downturn is 8.16%, granulating coefficient is reliably consistent inside a reasonable range, and the obvious warm downturn isn't happened.[8]

Piotr Grzes and Adam Adamowicz [2011] Presented paper on examination of circle brake temperature allotment during single easing back down under non-axisymmetric load . Introductory advance of the assessment subject to the as of late developed model where the intensity of warmth movement was believed to be reliably passed on the scouring surface of hover during hindering method, and the glow is moved just vital way, while during the sec

the three dimensional rotor is presented to the non-axisymmetric warm weight to imitate sensible warm lead of the brake movement. Movement conditions, thermo-physical properties of materials and estimations of the preventing instrument were gotten from the certified depiction of the hindering methodology of the explorer vehicle. Abstractly picked four estimations of the rates right now of brake duty were applied to the models to inspect their effect on the got game plans of the temperature improvements on the contact surface of the circle volume implying two confined restricted part examination. [9]

JIANG LAN et al. [2011] Presented paper on warm examination for brake plate of Sci/6061 Al. Compound co-relentless composite for CRH3 during emergency easing back down considering wind current

Cooling. The warm and stress assessments of SiCn/Al brake plate during emergency easing back down at a speed of 300 km/h considering wind stream cooling were investigated using constrained part (FE) and computational fluid components (CFD) techniques. All

of the three techniques for warmth move were separated. The most significant temperature after emergency easing back down was 461 °C and 359 °C without and with considering wind stream cooling, independently. The corresponding weight could show up at 269 MPa and 164 MPa without and with considering wind stream cooling, independently. The breeze stream through and around the brake plate was analyzed using the Solidwork2012 diversion programming group. The results suggested that the higher convection coefficients achieved with wind current cooling won't simply reduce the most extraordinary temperature in the easing back down yet what's more decline the warm inclines, since warmth will be ousted faster from all the more boiling bits of the disk[10]

Oder G. et al. [2009] Worked on warm and stress assessment of brake plates in railroad vehicles. Performed assessment oversees two cases of easing back down; the chief case considers easing back down to an end; the ensuing case considers easing back down on an incline and keeping up a consistent speed. In the two cases as far as possible condition is the glow movement on the hindering surfaces and the holding intensity of the brake calipers. What's more the outward weight is thought of. Constrained part procedure (FEM) approach is been used, 3D model has been shown for examination. Brake plate material is balanced graphite; two sorts of hover considered for thinks about one without wear and one with 7mm wear on the different sides. Most outrageous speed is 250 km/hr and the incorporating and initial circle and including temperature is 50 C Temperatures and stress in plates under

different weights are incredibly high. Regardless of the way that they are fulfilling the buyer's necessities for security, this assessment not considered shearing powers, extra weight and the cyclic weights during brake plates future. The results ought to be differentiated and test results [11]

Zaid, et al. [2009] Presented a paper on an assessment of circle brake rotor by Finite part examination. In this paper, the maker has driven an assessment on ventilated circle brake rotor of normal voyager vehicle with full stack of cutoff. The assessment is practically sure concern of warmth and temperature dissemination on plate brake rotor. In this assessment, restricted segment examination moved nearer has been coordinated in order to perceive the temperature spreads and practices of circle brake rotor in transient response. Exhibiting is done in CATIA and ABAQUS/CAE has been used as restricted parts programming to play out the warm assessment on transient response. Material used is Gray strong metal, with most noteworthy sensible temperature 550 C. For load examination 10 examples of breaking and 10 cycles without breaking (idle) action is seen as complete of 350 seconds. Result gave during first, fifth and during tenth cycle. Hence, this clear examination give better

perception on the warm attribute of circle brake rotor and help the vehicle business in making perfect and reasonable plate brake rotor.[12]

Talati and Jalalifar (2009), presented a paper on Analysis of warmth conduction in a plate brake system. In this paper, the regulating heat conditions for the circle and the pad are isolated as transient warmth conditions with heat age that is dependant to presence. In the enlistment of the glow conditions, limits, for instance, the length of easing back down, vehicle speed, geometries and the components of the brake parts, materials of the plate brake rotor and the pad and contact pressure appointment have been thought of. The issue is handled indicatively using Green's ability approach. It is deduced that the glow delivered as a result of scouring between the circle and the pad should be clearly dispersed to the earth to keep away from lessening the contact coefficient between the plate and the pad and to keep up a key good ways from the temperature rising of various brake parts and brake fluid vaporization due to over the top heating.[13]

Choi and Lee [2004] Presented a paper on Finite segment assessment of transient thermo adaptable practices in circle brakes. A transient assessment for thermo adaptable contact issue of hover brakes with frictional warmth age is performed using the constrained part procedure. To examine the thermo adaptable miracle occurring in plate eases back down, the coupled warmth conduction and flexible conditions (barrel molded headings) are handled with contact issue. Material used is carbon-carbon composite and wear is acknowledged unessential. The numerical multiplication for the thermo adaptable lead of plate brake is gotten in the reiterated brake condition. The computational results are presented for the transports of weight and temperature on each grinding surface between the arriving at bodies. It is seen that the orthotropic plate brakes can give favored brake execution over the isotropic one taking into account uniform and delicate weight scattering [14]

Masahiro Kubota et al. [2000] Presented paper on progress of a lightweight brake circle rotor: an arrangement approach for achieving a perfect warm, vibration and weight balance. This paper presents a parametric report that was coordinated dependent on an examination of wind stream through the ventilation holes similarly as a warm weight assessment and a vibration examination during easing back down. Taking into account the associations procured between rotor weight, shape and each display need, a strategy is presented for arranging a lightweight circle rotor. Computational fluid components (CFD) examination approach is used to envision the genuine technique. Short and gourd formed edges strategy had been used and the results affirmed that antisqueal execution was improved, and moreover a liberal weight decline was practiced differentiated and the example rotor shape

without causing cooling execution and warmth security from deteriorate.[15]

Toll Long Ho Et al. [1974] Investigated on the effect of frictional warming on brake material (Aircraft) and smoothed out assessment is coordinated to choose most vital segments which impact surface temperature. Where there are size and weight impediments the specific warmth and staying in contact an area appear to be a measure is suggested for choosing the number and thickness of brake plates, inside the limited space available in a wheel.[16]

III. CONCLUSION

Disc brake design plays as an important role in heat transfer as other variable like plate & vane thickness, fin material and flow pattern. There is a scope of improvement in heat transfer in ventilated disc brake if vane is angled and of alternate length other than straight radial vane. Contact time between air flow and vanes (time between air inlet and outlet flow through vanes) is also important factor in heat transfer from Disc rotor. There is also scope of research in improvement of heat transfer of rotor by increasing the contact time between vanes and air flow by design modification of vanes in such a way that fulfills the requirement.

REFERENCES

1. Praharsha Gurram , Shravan Anand Komakula , G.Vinod Kuma32 " Design and Analysis of Vented Disk Brake Rotor" International Journal of Applied Engineering Research,ISSN 0973-4562 Volume 14, pp. 2228-2233, 2019
2. A.Naga Phaneendra, S. Junaid Razi, Wasee Ul Kareem L, G. Md. Adnan and S. Md. Abdul Ahad , " Thermal Analysis Of Solid Disk Brake Rotor" International Journal Of Mechanical And Production Engineering Research And Development (Ijimperd), Issn(P): 2249-6890; Issn(E): 2249-8001, Vol. 8, Issue 2, Apr 2018, 1039-1048
3. Pravin Mohan and PatelSudheendra S , " Design and Analysis of Titanium Caliper Disk Brake" International Journal of Engineering Development and Research, Volume 5, Issue 1 |ISSN: 2321-9939, PP 144 – 158, 2017
4. S. Arvin Rao, MuhamadAnuwarJusoh, Abd Rahim Abu Bakar*, "REDUCTION OF Disk BRAKE SQUEAL NOISE USING CONSTRAINED LAYER DAMPERS"JurnalTeknologi (Sciences and Engineering),83–87, 2017
5. Yugesh Anil Kharche and Prof. DheerajVerma " Design And Fem Based Analysis Of Disk Brake For Four Wheeler" International Journal of Mechanical Engineering Research and Technology, vol.1 July 2014
6. K. M. Muniswamy, "Warmth move upgrade on ventilated brake circle with cutting edge tendency edge variety", global diary of car innovation, vol. 14, No. 4, PP.569-575, 2013
7. K. Sowjanya, "Structural investigation of circle brake rotor", International Journal of PC patterns and innovation (IJCTT)- volume 4 , Issue 7-July 2013
8. Zhang Jian, "Exploration of the transient temperature field and contact properties on circle brakes", Preceeding of the second International gathering on PC and data application ICCIA, 2012.
9. PiotrGrzes and Adam Adamowicz, "Analysis of plate brake temperature circulation during single slowing down under non-axisymmetric load", Applied warm building 1003- 1012., 2011
10. JIANG Lan, "Thermal examination for brake plate of Sci/6061 Al. Compound co- persistent composite for CRH3 during crisis slowing down considering wind current cooling" ,Trans. Nonferrous Met. Soc. China,2783-2791., 20011
11. Oder, G., Reibenschuh, M., Lerher, T., Sraml, M.; Samec, B.; Potrc, I. "Warm And Stress Analysis Of Brake Disks In Railway Vehicles" at International Journal of Advanced Engineering , ISSN 1846-5900, 2009
12. Zaid, M.A., Radzai, M.S., Ahmad, R., Ridzuan, M.M., Nurfaizey, A.H., and Afzanizam, M.M.R , "An examination of plate brake rotor by Finite component investigation", Journal of Advanced Manufacturing and Technology, Vol. 3, pp 37-48 ,2009
13. Talatia Faramarz and Jalalifar Salman, "Examination of warmth conduction in a plate stopping mechanism", Heat Mass Transfer, V 45, pp1047–1059 ,2009.
14. Choi Ji-Hoon and In Lee "Limited component examination of transient thermo versatile practices in circle brakes" ,Wear, V 257, pp47–58 ,2004
15. Masahiro Kubota., "Development of lightweight brake plate rotor: A structure approach for accomplishing an ideal warm, vibration and weight balance." JASE ,349-355., 2000
16. Ting-Long Ho., "Impact of frictional warming on brake materials", Wear, pp73-91, 1974
17. Barba, E., Excelencia en el proceso de desarrollo de nuevos productos. EADA Gestión. Barcelona.1993
18. De Castro, M., Biblioteca técnica y práctica de la motocicleta. Suspensión, dirección y frenos. CEAC,2001
19. De la Cruz, C., El control de la calidad en la fundición (parte I). Fundidores: fundicones férreas en field, coquillay fundición a presión 119, 32-38., 2004
20. Directiva CEE relativa al frenado de los vehículos de engine de dos o tres ruedas. 93/14/CEE. Diario oficial de las Comunidades Europeas. 5 deAbril de 1993.
21. Farrer, F., Minaya, G., Niño, J., Ruiz, M., Manual de Ergonomía. MAPFRE, S.A. Italtipresse, fabricante de equipos de inyección para aluminio. Disponible en <http://www.italtipresse.it/Motorcycles> makers, Aprilia, disponible en: <http://spain.aprilia.com/>; Kawasaki, disponible en: <http://www.kawasaki.es/>; Ducati, disponible en: <http://www.ducati.es/>; Honda, disponible en: <http://www.honda-montesa.es/>;



- Suzuki, disponible en: <http://moto.suzuki.es/>;
Yamaha, disponible en:
<http://www.yamaha-motor.com/>,1995
22. Ulrich, K., Eppinger, S., Product structure and advancement. Boston, MA: Irwin McGraw-Hill,2000
23. M. Nouby, D. Mathivanan, K. Srinivasan, A joined methodology of complex eigenvalue examination and structure of trials (DOE) to consider circle brake screech, International Journal of Engineering, Science and Technology Vol. 1, No.1, 2009, pp. 254-271
24. P. Liu a, H. Zheng a, C. Cai a, Y.Y. Wang a, C.Lu a,K.H. Ang b, G.R. Liu, Analysis of plate brake screech utilizing the mind bogging eigenvalue strategy, ScienceDirect, Applied Acoustics 68 (2007) 603–615
25. Rajendra Pohane, R. G. Choudhari, Design and Finite Element Analysis of Disk Brake, International J. of Engg. Exploration and Indu. Appls.(IJERIA). ISSN 0974-1518, Vol.4, No. I (February 2011), pp 147-158
26. H Mazidi, S.Jalalifar, J. Chakhoo, Mathematical Model of warmth conduction in a plate stopping mechanism during slowing down, Asian diary of Applied Science 4(2): 119- 136,2011, ISSN 1996-3343/DOI:10,3923/ajaps,2011,119,136
27. V.M.M.Thilak, R.Krishnaraj, Dr.M.Sakthivel, K.Kanthavel, Deepan Marudachalam M.G, R.Palani , Transient Thermal and Structural Analysis of the Rotor Disk of Disk Brake , International Journal of Scientific and Engineering Research Volume 2, Issue 8, August - 2011 ISSN 2229- 5518
28. Prashant Chavan, Amol Apte, Axisymmetric analysis of shot circle brake gathering to assess warm anxieties TATA engines ltd. Pimpri, Pune-411018. India 91-20-5613 3159
29. Q Cao1, M I Friswell, H Ouyang, J E Mottershead1 and S James, Car Disk Brake Squeal:Theoretical and Experimental Study Materials Science Forum Vols. 440-441 (2003) pp. 269-276 © (2003) Trans Tech Publications, Switzerland
30. S. P. Jung, T. W. Park, J. H. Lee, W. H. Kim, and W. S Chung, Finite Element Analysis of Themalelastic Instability of Disk Brakes, Proceedings of the World Congress on Engineering 2010 Vol II WCE 2010, June 30-July 2, 2010,