Research Journal of Recent Sciences ISSN 2277-2502
Vol. **4(1),** 62-67, January **(2015)** *Res.J.Recent Sci.*

Analysis of V-Slotted Brake Liner in Light Weight Commercial Vehicles

Bire Sarang and Thube Yogesh
School of Mechanical and Building Sciences, VIT University, Vellore, Tamilnadu 623014, INDIA

Available online at: www.isca.in, www.isca.me
Received 14th November 2013, revised 25th January 2014, accepted 25th May 2014

Abstract

Commercial vehicles are introduced with more powerful engines with improved performance requirement now days; increased capability makes performance of brake system and safety as a prime parameter during transportation. New techniques of crossdrilling on discs, advance in liner material are introduced to enhance brake performance and life. In this paper behavior of friction liner for light commercial vehicle is analyzed with help of CAE tools, also excitation of liner material under vibrating load and harmonic excitation of liner surface is studied. Modification in existing brake liner geometry is suggested through introduction of V-slots over curved surface of liner material. Reasoning behind providing slotted geometry is explained in due course of paper. Effect of modified brake liner substantially improve liner performance through reduced directional and total deformation of liner , also frequency analysis shows that effective area of total deformation is reduced with modified liners .Along with this, stress intensity across liner face is studied and results are compared with unmodified one , through CAE analysis it is clear that modified liners provide improved performance through reduced deformation and additional benefits such as improving brake cooling and providing de-gassing

Keywords: Brake Liner, Deformation, Stress Concentration, ANSYS CAE, Brake Drum, Slotted Liners.

Introduction

Brake pad wear is a major factor in determining the maintenance intervals for vehicles, now a day's requirements on the service life of brake pads are steadily growing in line with the demand for increased maintenance intervals. Any step in improving pad life and thereby increase maintenance intervals. This requires fundamental studies on new and advanced friction materials. Contact wear is essentially influenced by two factors, the friction power acting at the contact surfaces, which is in turn a function of brake pressure, friction coefficient and driving speed, and the temperature at the friction surface.

This paper focuses its attention over improving braking performance of vehicle through modification in brake liner, its effect been studied and analyzed in CAE tools. Following points are covered under this study i. modification of brake liner through provision of v – slotted feature over liner surface. ii. Analysis of modified liner performance and comparison with base unmodified liners. Problem is analyzed in ANSYS with specified boundary conditions of friction contact, rotating loading and brake pressure application. Analysis is carried out taken into consideration extreme conditions of operation and brake pressure application, high wear resistant materials such as asbestos, epoxy resins are taken into account for analysis. Results thus obtained is compared with unmodified brake liner and compared on basis of total deformation, directional deformation and stress intensity across brake liner. Data for load application and operating conditions is collected from standard tests carried out in references. Data for dimensions and material properties is referred from standard literature[1,2].

Table-1
Brake Drum properties and dimensions

Drum dimensions and properties	**Value**
Outer drum diameter,	360mm
Inner drum diameter,	340mm
Inner drum cap diameter,	160mm
Outer drum cap diameter,	340mm
Height of drum cap,	10mm
Diameter of holes centerline,	220mm
Height of drum,	150mm
Holes diameter(6),	10mm
Inner diameter of upper ring,	360mm
Outer diameter of upper ring,	360mm
Height of upper ring,	15mm
Density of drum,	7350 kg/m^3
Young's modulus of drum,	1200 GN/m^2
Poisson ratio of drum.	0.27

Selection of brake shoe material and dimensions is done on basis of application and mostly used models, here most commonly used configuration is considered for analysis and both modified and unmodified are considered with same properties[3].

Literature Review: *David Antanaitis and Anthony Rifici* in their paper "The Effect of Rotor Crossdrilling on Brake Performance" studied effect of cross drilling on brake disc through testing on dynamometer, three case studies are considered as with cross drilled and without cross drilled and testes are carried out at different operating conditions to compare results on basis of Rotor Cooling, Brake Output / Fade, Lining Wear

Lining and shoe dimension properties	value
Thickness of lining	12mm
Width of lining	120mm
Thickness of shoe	4mm
Width of shoe	120mm
Thickness of shoe rib	4mm
Height of shoe rib	20mm
Lining arc	120^0
Shoe and rib arc	140^0
Hole diameter	10mm
Slot depth	12mm
Slot length	10mm
Density of lining	1350 kg/m^3
Young's modulus of lining	200 MN/m^2
Poisson ratio of lining	0.23
Density of shoe	7800 kg/m^3
Young's modulus of shoe	2000 MN/m^2
Poisson ratio of shoe	0.27

Figure-1
Brake Shoe and Liner for light weight commercial Vehicle

D.M. Elzey and R. Vancheeswaran S. W. Myers and R. G. McLellan in their paper "Intelligent Selection of Materials for Brake Linings" developed software engineering tool for correct material selection of brake liner material selection and thus making it easier for proper selection of material for complex selection of material for friction contact analysis. *Dragan Aleksendric and Velimir Cirovic* in study paper "Effect of Friction Material Manufacturing Conditions on Its Wear" specified effect of friction material manufacturing on performance characteristics of liner. Study of literature and research work reveled that proper selection of friction material is key parameter for brake performance and modification of friction material will only be performed.

Methodology

Project Methodology: Concept of break drum used in automobiles to for safety purpose and reduction of speed of vehicle generally drum break on rear wheel side. The most advantage of the drum brake is the self energizing nature of the brake, which helps in reducing the required actuating force. Most of time failure of the friction material of the brake shoe might occur before the friction material ends its wear life. Up till there is a experimental method is available to analyze pressure distribution in break, in this paper we are going to analyze behavior of break liner under extreme condition with help of ANSYS - Structural and Modal analysis and modeling of all components is done in prepare model by using Pro-e.

This study consist of analysis of modified (V-slotted shoe liner) and unmodified shoe model of light weight commercial vehicle. Analysis results are compared on basis of excitation frequency response of liner body, harmonic response and total, directional deformation and results are compared.

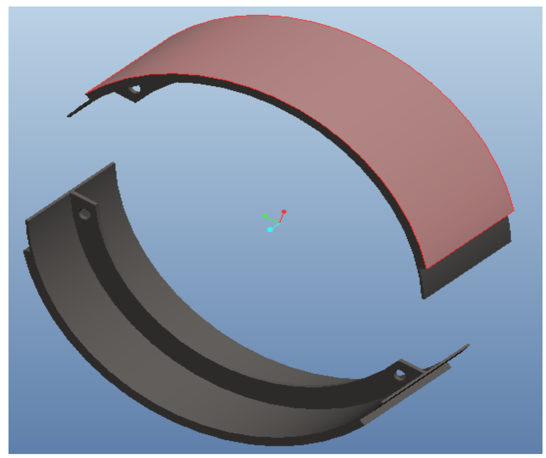

Figure-2
Break shoe, Base Model

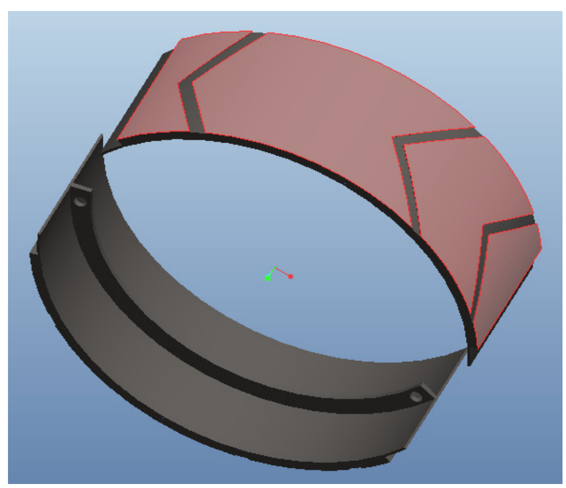

Figure-3
V-Slotted break shoe, Modified

V–Slotted Brake shoe: Slots on brake shoe are provided taking into consideration its direction of rotation, its leading edge friction contact and frictional requirement at start of liner surface. Total three slots are provided n liner surface first slot on leading side is provided with less slope as compared to others and covers less length over liner surface , This slot mainly useful for reducing directional deformation of liner and achieving uniform deformation over surface , Second and third slots are mainly given for reducing total deflecting of friction material at time of braking and equalizing deformation all over surface , Thus reducing possibility of maximum deformation and providing improved life .

Along with above discussed properties it will also help in providing proper degassing and cooling of liner.

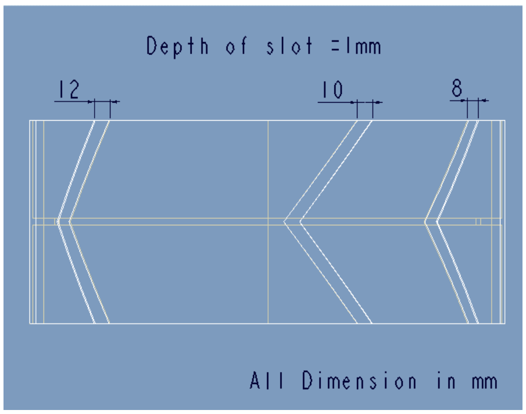

Figure-4
Dimension of V-slotted Brake Shoe

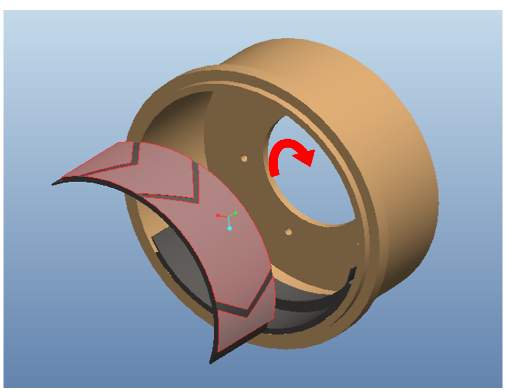

Figure-5
Assembly details of Brake Drum

General methodology adapted for analysis in CAE tool is given in general steps. Steps are described with parameters specified in along with each step and conditions applied[5,6].

Engineering Data: Material of structural steel and high wear resistant materials such as asbestos, epoxy resin etc with higher frictional contact properties are considered.
Geometry Setup: Geometry consists of break drum and break shoe liners which are modeled and assembled in PRO-E and then imported in DESIGN MODELER in ANSYS 14.0.

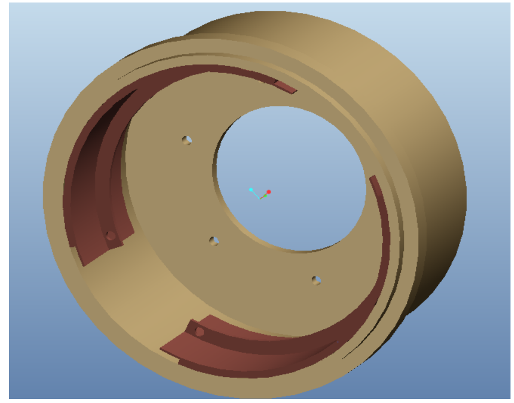

Figure-6
Assembly of Brake Drum and Shoe

Meshing: Meshing is necessary to simulate the moving boundary technique. Mesh quality has major influence on the results. Element size should be small. Poor mesh affects numerical accuracy and convergence. Meshing consist of smooth and fine sizing, smooth automatic inflation, triangle surface mesher, node, elements Skewness determines the closeness of element. Based on this tetrahedron mesh generated because tetrahedron has four corners, six edges and four faces. Tetrahedron has high quality mesh and it is used for meshing of complex 3D geometries. Some of meshed geometries are shown

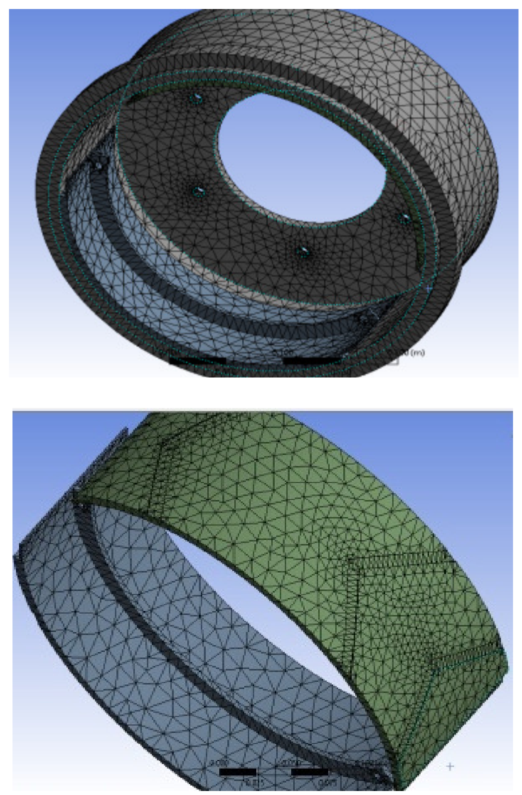

Figure-7
Geometry meshing

Problem set up and solution: Boundary conditions are set up in problem considering rotational velocity to break drum, one end of shoe is fixed and uniform pressure applied on shoe surface, displacement on shoe given in only one direction i.e. in direction of shoe expansion, application.ent is applied on shoe surface , all numerical values for this calculation is calculated taking into consideration braking operation at extreme operating conditions .After setting these boundary condition analysis is carry out by using analysis type static structural and is solved by using mechanical APDL (Ansys Parametric Design Language) solver.

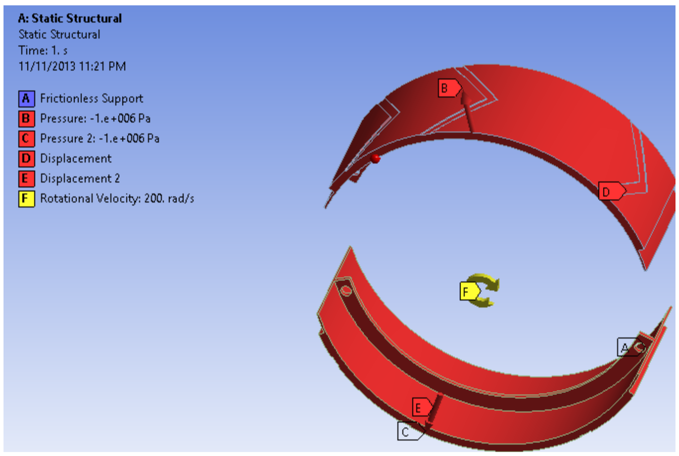

Figure-8
Boundary conditions

Results and Discussion

Harmonic Response: Harmonic response of liner material is analyzed on basis of braking force excitation acting on contact surface , Lower portion of brake liner is assumed to be fixed for simplification propose . Results are analyzed and counter of deflection against excitation frequency is plotted, along with pressure magnitude counter for liner material. Through analysis response of modified brake liner is increased from frequency of 400 Hz to 500Hz, maximum deflection is given at higher frequency.

Modal Frequency Response: Frequency response gives us maximum deflection at above discussed harmonic response frequency, Modal analysis shows that maximum deflection is found at start of shoe where braking pressure is at its maximum value during brake application, With provision of V-Slots point of maximum deflection is shifted at distance away from maximum pressure zone and thus helps in reducing maximum deflection at high pressure zone.

Total Deformation: Total deformation is analyzed in CAE with selection of braking conditions on liner surface, Extreme braking pressure is assumed to be applied with vehicle is assumed to be at its maximum speed. Counter of maximum deformation is uniform for both models and there is no major difference found over surface.

Depth of V-Slot provided however provides reduction in total deformation in case of modified model but provision of depth will reduce strength of liner material, here we have kept depth of V-Slot limited to 1mm and followed same for all analysis.

Directional Deformation: This is the important parameter where most of brake liner will have key deciding points and prime cause for earlier failure. Directional deformation is considered in direction of brake force application. It is maximum at leading point of shoe and reduces over its length. In case of modified shoe liner Directional deformation is found to be uniform all over surface.

Reduction in directional deformation will reduce the wear of nonuniform spots over brake surface.

Stress Concentration and Intensity: Stress concentration is limiting factor in incase of design including slots and notches and affects adversely strength of base component, Providing slots on brake liner will be questionable as it will introduce the stress concentration on surface . Sufficient care and iterations is done to give up required depth and length of slot in order to have reduced and uniform stress intensity. Stress intensity is found to be increasing wit depth of slot provide optimal depth of 1 mm is given to have stress intensity within safe range material. Modified V slotted is observed to have stress intensity at edge of slot provides and its intensity is observed within safe range of material. Base model observed to have increased stress intensity at start of shoe and maintaining it uniform all over surface.

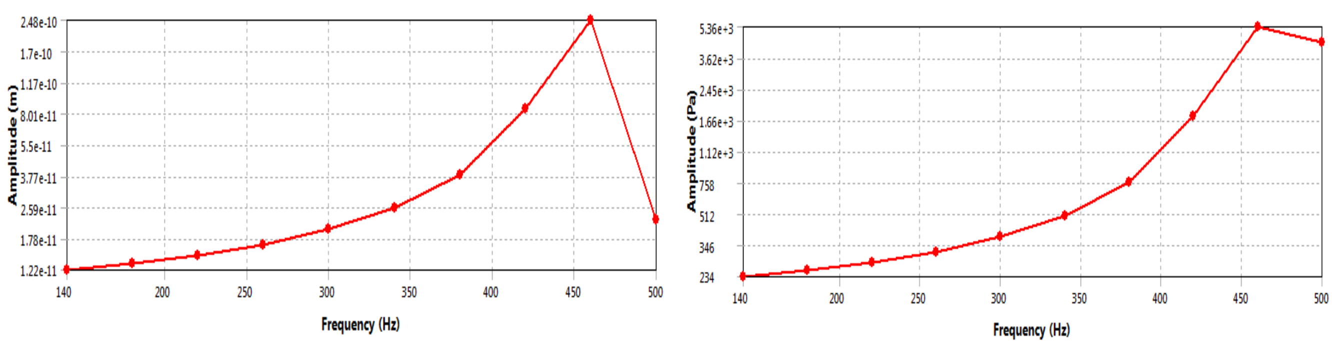

Figure-9
Frequency and amplitude response plot for Base Model

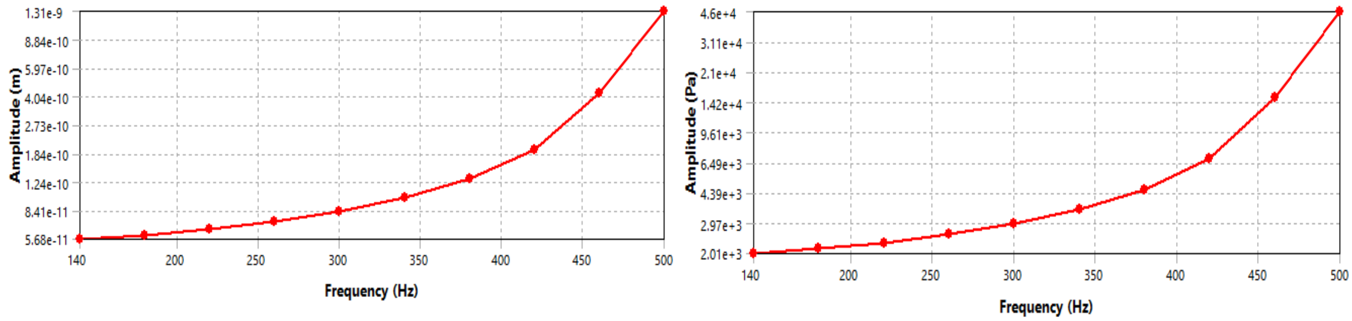

Figure-10
Frequency and amplitude response plot for Modified Model

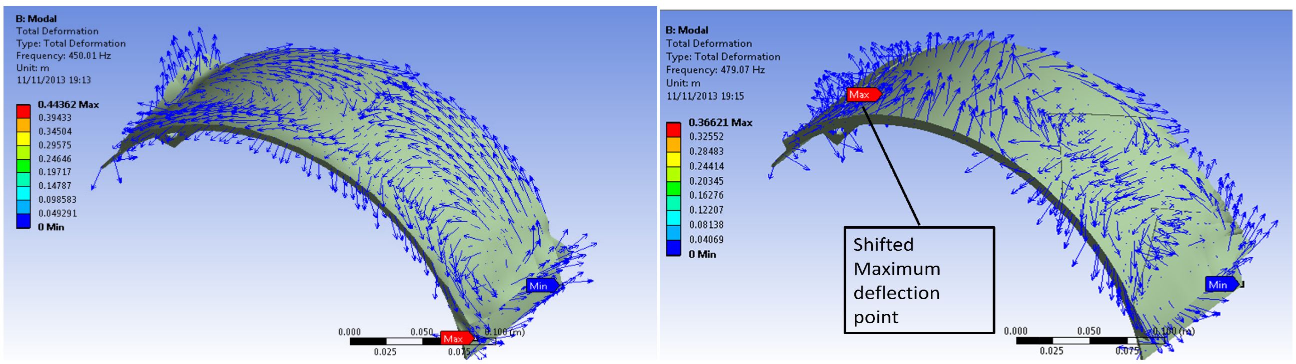

Figure-11
Frequency and deflection response of Base and Modified liner Model

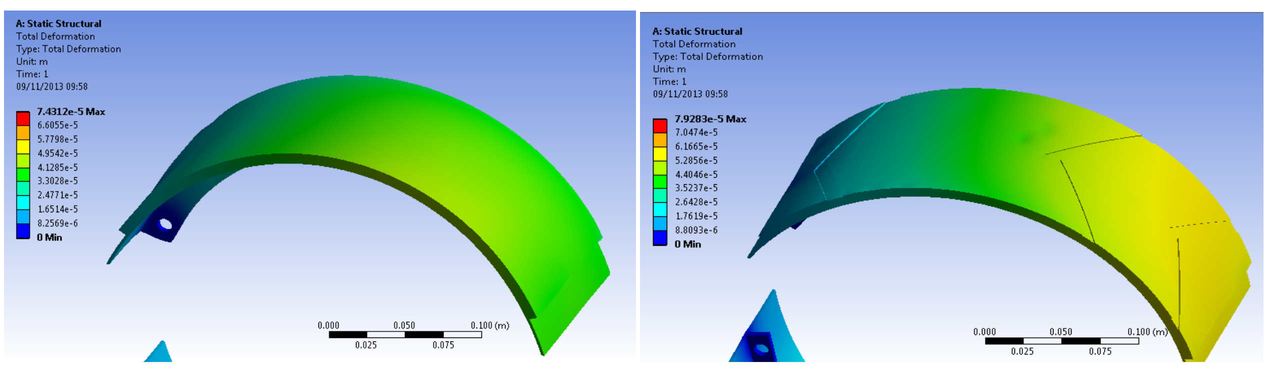

Figure-12
Total Deformation Base and modified model

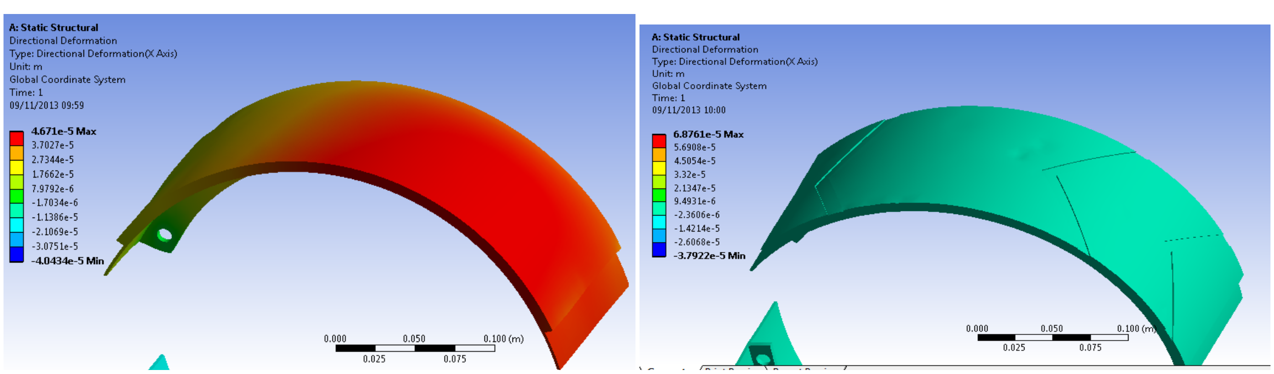

Figure-13
Directional Deformation Base and Modified model

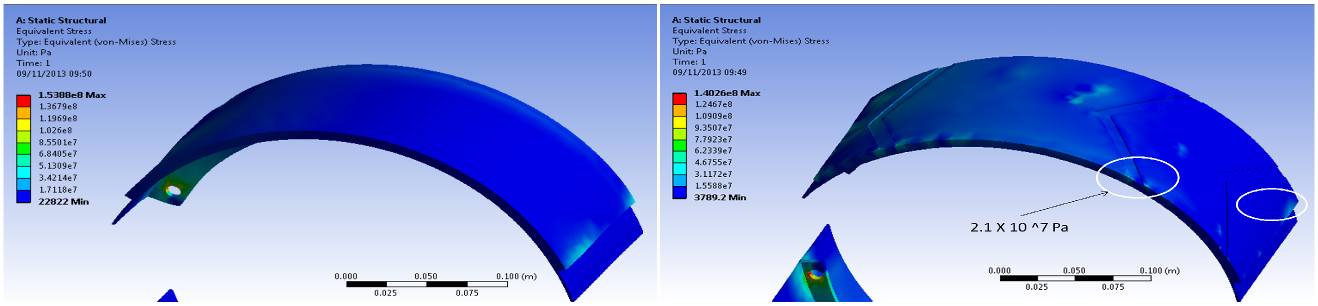

Figure-14
Stress intensity of Base and Modified Model

Conclusion

Through above discussion on different parameters we can conclude that modified V-slotted brake shoe is preferred over convention one when we compare their performance. Directional deformation of liner surface and reduced total deformation under harmonic excitation frequency is key parameter which gives favorable results.

Consolated values of parameters found out from CAE analysis is tabulated below,

Table-3
Conclusion values

Parameters	Base Model	Modified Slot
Total Deformation(Meter)	5.33×10^{-5}	5.20×10^{-5}
Directional Deformation(Meter)	4.67×10^{-5}	3.32×10^{-5}
Equivalent Stress, Pa	1.71×10^{7}	2.1×10^{7}

Computed results shows that total deformation and maximum directional deformation in case of V-Slotted liners is reduced as compared to the base model. However stress concentration of V-Slotted liners is increased at some localized slotting Edges.

References

1. Dadrasi Ali, Buckling of Cracked Conical Frusta under Axial Compression, *Res. J. Recent Sci.,* 2(2), 33-39 **(2013)**

2. Ali Dadrasi, On the Effect of Imperfection on Buckling load of Perforated Rectangular Steel Plates, *Res. J. Recent Sci.,* **2(3),** 36-43 **(2013)**

3. Kumar Krishan and Aggarwal M.L., A Finite Element Approach for Analysis of a Multi Leaf Spring using CAE Tools, *Res.J.Recent Sci.,* **1(2),** 92-96 **(2012)**

4. Ahmed Ibrahim, Modeling of Vehicle Drum Brake for Contact Analysis Using Ansys ,SAE 2012-01-1810, **(2012)**

5. Yoneda Adrian, Costa Álvaro, Souza Álysson, Cunha Rodivaldo, Travaglia Carlos Abilio Passos, Benincá Evandro, Araújo João and Bochi Marcelo, Analysis of Drum Brake System with Computational Methods, SAE 2013-36-0022, **(2013)**

6. Elzey D.M., Vancheeswaran R., Myers S.W. and McLellan R.G., Intelligent Selection of Materials for Brake Linings, SAE 2000-01-2779, **(2000)**

7. Hohmann Ch., Schiffner K. and Brecht J., Pad Wear Simulation Model, SAE 1999-01-3392, **(1999)**

8. Garrett T.K., Newton K. and Steeds W., The Motor Vehicle Thirteenth Edition, chapter 32 Servo- and power-operated, and regenerative braking systems, 983-1014, **(2001)**