Design Analysis and Performance evaluation of discrete moulded liner buttons on band in terms of performance of brake as load fade and speed fade.

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Abstract—- *Fade is the term used to indicate a loss of braking effectiveness at elevated temperatures because of a reduction in the kinetic friction coefficient (μ). The fade phenomenon in friction materials represents a deviation from law of friction and its occurrence reduces braking efficiency and reliability. Three primary attributes governing brake fade have been identified as load fade, speed fade and temperature fade. High interfacial temperatures can lead to a decrease in shear strength of the pad and consequently a decrease in frictional force which induces fade. This paper deals with application of molded liner buttons to induce temperature reduction at the brake liner interface by increased air circulation. This is expected to improve brake torque; brake power absorbed and reduced brake wear. Material of brake liner for discrete molded liner buttons is FTL097.*

Index Terms— *air circulation, brake fade, discrete moulded liner buttons*

INTRODUCTION

Brake friction materials consist of four classes of ingredients viz., binder - a thermo-setting resin (mostly phenolic), fibers, fillers and friction modifiers. Each class of material significantly contributes towards effective braking performance. In the case of brakes operating temperature of the rotor drums and pads can go up to 200-250° and 370° C respectively due to severe and repetitive breakings. Such high interfacial temperatures lead to decrease in shear strength of the pad and consequently decrease in frictional force causing "Fade" [2]. Loss in braking effectiveness at elevated temperatures (300°C-400°C) because of reduction in friction coefficient and the revival of the same at lower temperatures is referred to as fade and recovery respectively. The temperature sensitivity of friction materials is a critical aspect while ensuring their smooth and reliable functioning. The temperature sensitivity of the friction materials influences the thermo-elastic-instabilities, which in turn alters the friction performance at the braking junctions.

The band for the band brake is prepared in a different form that allows overall cost reduction, ease liner replacement and lowered maintenance cost of brake.

LITERATURE REVIEW

Bouchetara Mostefa , Belhocine Ali (2014) this research work shows the analysis of thermo-mechanical behavior of dry contact between brake disc and pads during the braking phase.[1] Modeling of transient temperature in disk was done to install ventilation system in vehicles. This analysis further coupled to determine the Von-Misses stress, deformation and contact pressure distribution in pads. The results obtained were satisfactory when comparison was done with specialized literature survey.

Dr. S.B.Chikalthankar, Dr. V.M. Nandedkar this research work represents the study of frictional and wear characteristics of non-asbestos brake pad using Link chase machine. Parameters like coefficient of friction and wear were considered foe the work study. This study outlined a proposed work to develop a non-asbestos material which is expected to show a stable friction coefficient and wear rate. [2]

K.Sowjanya and S. Suresh (2013) this work explains the structural analysis of disk brake rotor and its effect on the brake disk design. Study was carried on the basis of strength and rigidity criteria. Materials like aluminum metal matrix composites were examined for thermal solution to structural analysis. Maximum Von-Misses stress was observed to be 50.334 MP a for CI and211.98MPa for AIMMCI and 566.7 MP a for AMMCII [3]. The design is found to be safe.

M.A. Maleque, A. Atiqah (2012) objective of this work was to develop a new natural fiber reinforced Aluminum composite for automotive brake pad application. Properties like density, porosity, microstructures analyses, hardness and mechanical properties were examined using dens meter, UTM, hardness tester. Four new formulations were prepared by varying coconut fiber content from 0, 5, 10, 15% volume fractions. Results obtained were concluded that 5 & 10% volume fraction showed better physic-mechanical properties compared to other fractions [4]. And it verified that coconut fiber can be used as potential filler material.

A.M.Zaharudina, R.J.Talib (2012) studied Taguchi method for optimizing the manufacturing parameters of frictional materials like semi-metallic materials produced using powder metallurgy. Factors like physical properties like hardness, specific gravity and triblogical properties like wear, fade were considered as processing parameters. Results concluded that molding pressure has the strongest effect and impact on physical as well as triblogical properties. [5]

Zaid (2009) conducted study on ventilated disc brake rotor of normal passenger vehicle with full load capacity. [6] Study concerns with heat and temperature distribution on rotor. FEM approach was used and modeling was done in CATIA. For study purpose 10 cycles of braking and 10 idle cycle were taken into consideration. Material used was gray cast iron at a temperature of 530^{o}.This study provide a better understanding on thermal behavior of gray cast iron and also helped to find and develop an optimum rotor system for automotive industry.

Ji-Hoon, Choi & Lee (2004) carried work on transient analysis for thermo elastic contact problem of disk brake. For this work material used was carbon, carbon composite and wear was assumed to be negligible. Two disks were considered one isotropic and other orthotropic. Pressure and temperature distributions were numerically computed at the disk surfaces at different braking conditions. The final results computed showed that orthotropic disc brakes provides mild pressure distribution and are therefore more better and optimum, performance level wise over the isotropic brake disc.[7]

Masahiro Kubota (2000) this paper represents the research work carried for achieving an optimum thermal, vibration and weight balance of brake disc rotor.[8] Analysis was done on the airflow through ventilation holes, thermal stress analysis and vibration analysis during braking. Computational fluid dynamics was used to analyze the actual performance. Substantial weight reduction was achieved without deteriorating cooling performance by obtaining relationship between rotor weight, shape and other performance parameters.

Malcolm K. Stanford (2001)

This paper presented work on friction and wear behavior of four hard coatings using pin-on disk machine. The four coatings were of Ni, Cr, Fe, Si, and Metco. Cylindrical pins machined from non-asbestos organic compounds and coated and uncoated disks were slide over each other. Properties like hardness, porosity and corrosion resistance were processed. Lowest wear was observed when lining material slide against stellate coated disc. High friction coefficient was observed for Metco coated disc. [9]

EXPERIMENTATION

Design and analysis of the band brake individual liner.

Arrangement of brake band, material selection of brake liners and the layout of the band are as follows:

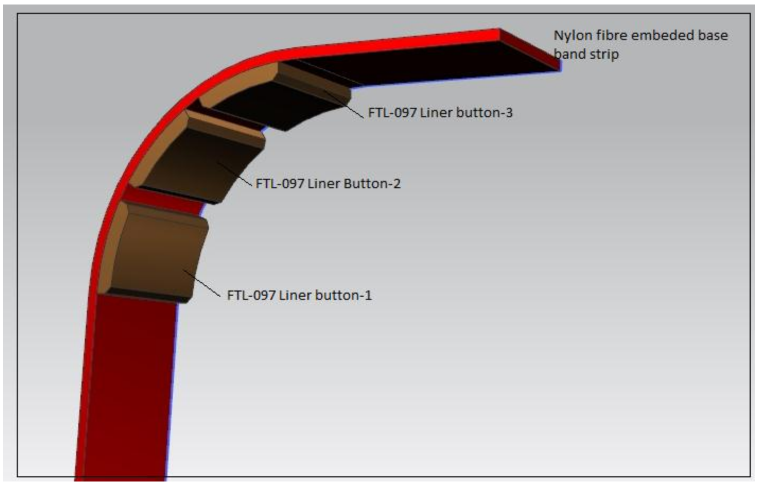


Figure 1: Discrete FTL-097 button liner

- Base band is a nylon fibre based strip for holding purpose on which the liner buttons are mounted.
- Liner buttons are made of brake liner material in the moulded form , and it is mounted on the base band in the discrete (separate) form in order to introduce air gap between two liners such that it allows passage of air that facilitates the cooling of the liner buttons and thereby aiding to avoid brake fade. Material properties of the Discrete molded liner button:

Figure 2: FTL-097 Liner

FTL-097 is a rigid material having a non-asbestos base. It is grey in color and incorporates a blend of selected friction modifying agents. This complex matrix of ingredients is consolidated with a specially developed binder system. FL-097 has a high friction coefficient which is combined with an excellent resistance to fade and wear. Its high performance characteristics are particularly suited to severe duty applications. This material although not intended to operate in oil is not physically damaged by moderate oil contamination. Material is certified to non-sparking. It has excellent resistance to fade and wear.

- Applications: Brake pad for cranes, geared discs

Design and analysis of the band brake individual liner under given system of forces the input parameters for the same are shown below

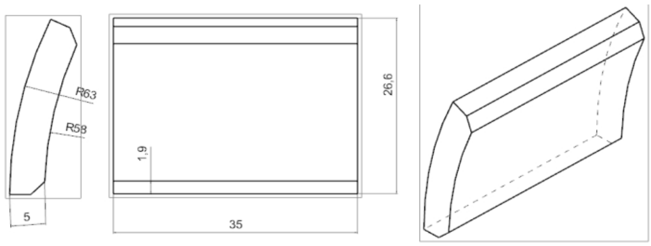


Figure 3: Geometry of discrete liner

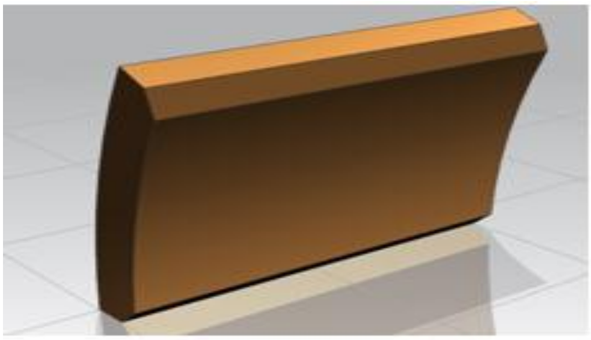


Figure 4: FTL-097 liner

Table No. 1: Physical properties

Density g/cm	1.94-1.99
Hardness	(SHORE-D) 87-90
Acetone extraction	< 2%
Min. assembly shear strength	400 N/cm^2

Geometry was developed using UGNX-8 and STEP file was used to import geometry to ANSYS work bench

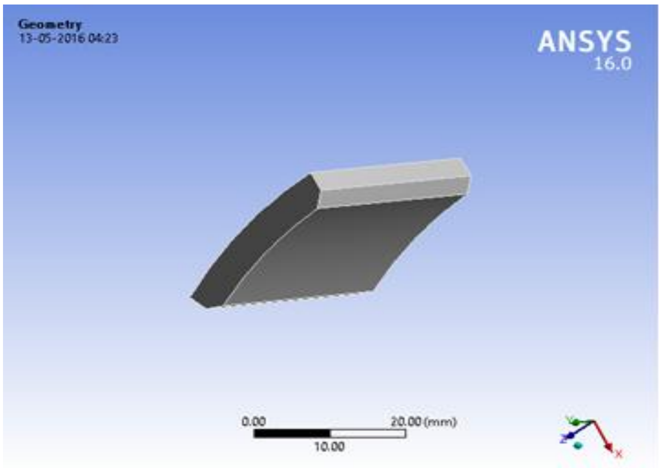


Figure 5: Geometry

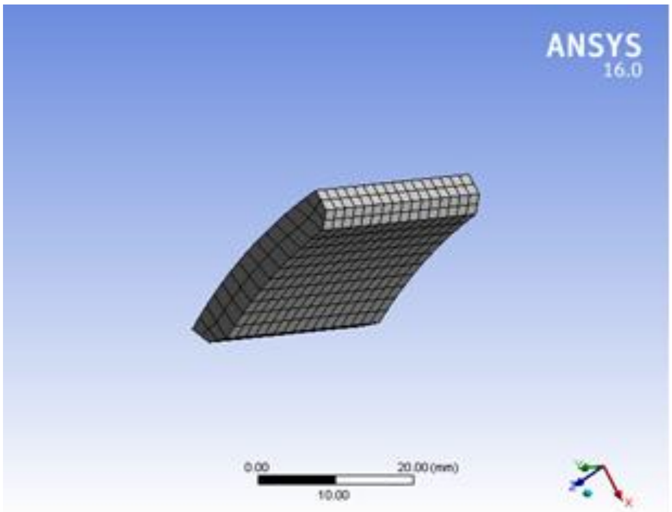


Figure 6: Meshing

Table No. 2: Free Meshing Parameters with tetrahedron elements

Nodes	2709
Elements	448
Mesh Metric	None

Boundary conditions and loading for the analysis were applied as below:

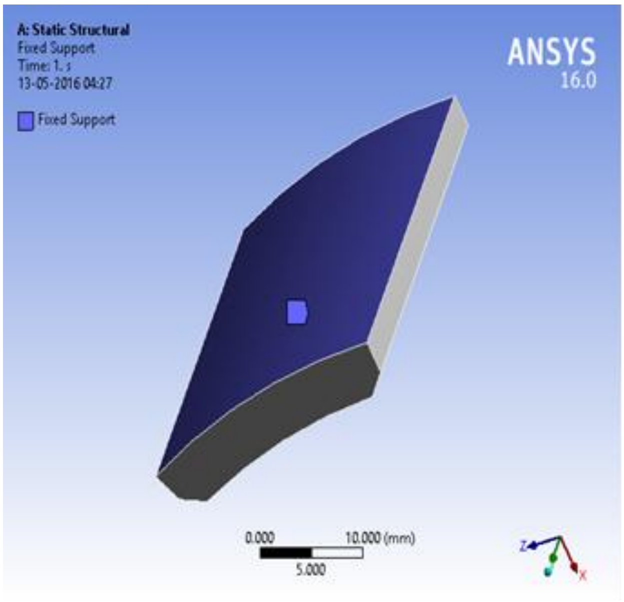


Figure 7: Boundary conditions

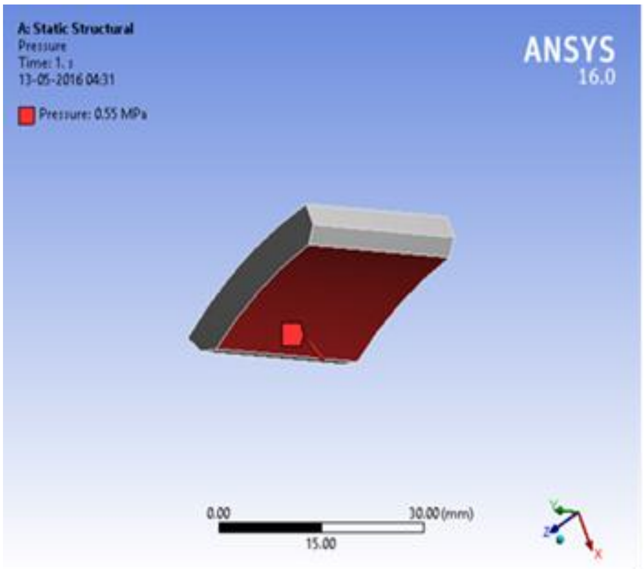


Figure 8: Pressure intensity

Maximum allowable press of 0.55 N/mm2 for the brake band on the cast iron wheel was taken to be 0.55 MP a

Figure 10: Equivalent Von-misses stress

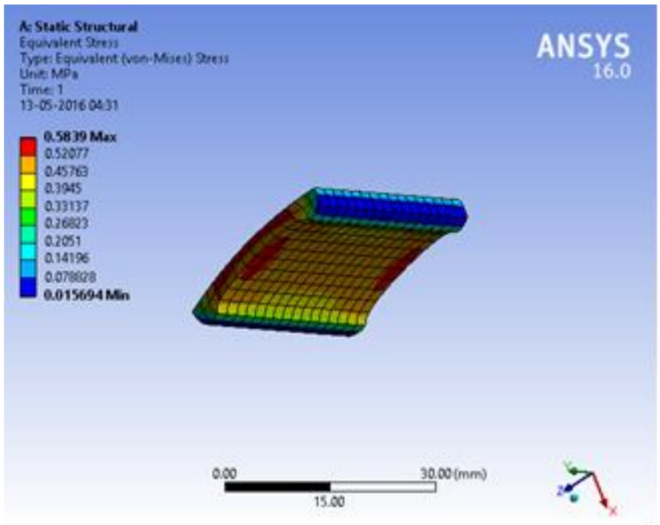


Figure 9: Equivalent Von-Misses Stress

As the Equivalent Von-misses stress 0.5839 N/mm^2

Allowable stress of 4 N/mm^2 the brake liner is safe.

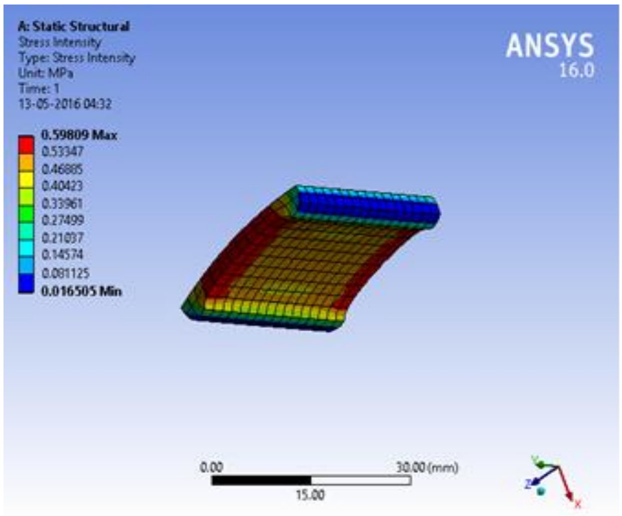


Figure 10: Von-Misses stress

As the maximum stress intensity 0.598 N/mm^2

allowable stress of 4 N/mm^2 the brake liner is safe.

Test and Trial on the Brake Liner:

Procedure:

1. The band is loaded on the test mechanism.

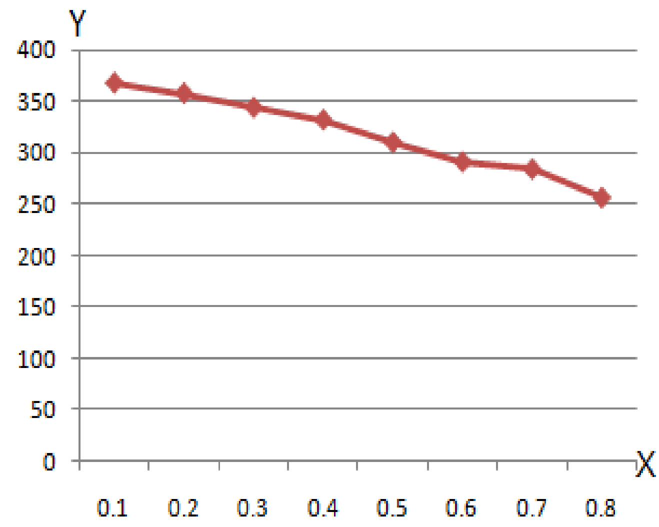
2. The motor is started and the no-load speed is measured and noted using a digital contact less tachometer.
3. The load pan is added with a load of 100 grams; speed of the load drum is measured again and noted.
4. The procedure is repeated with increment of 100 grams up to 800 gm. Load

RESULT TABLE

Table No 2: Values obtained after test and trial

Sr no	Load (kg)	Speed (rpm)	Braking Torque (N-m	% Decelration	Fade dimension mm/10000 cycles	Fade volume mm3/10000cycles
1	0.1	368	0.056898	5.64102	0.01	3.103333
2	0.2	358	0.113796	8.20512	0.01	3.103333
3	0.3	344	0.170694	11.7948	0.015	4.655
4	0.4	332	0.227592	14.8717	0.015	4.655
5	0.5	310	0.28449	20.5128	0.018	5.586
6	0.6	291	0.341388	25.3846	0.02	6.206667
7	0.7	284	0.398286	27.17949	0.02	6.206667
8	0.8	256	0.455184	34.35897	0.022	6.827333

SPEED (RPM)

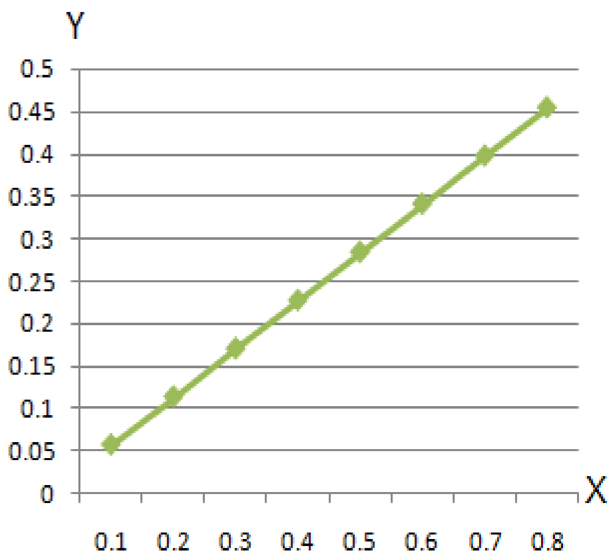


LOAD (KG)

Figure 11: graph of speed vs brake load

Drum speed drops with increase in brake load.

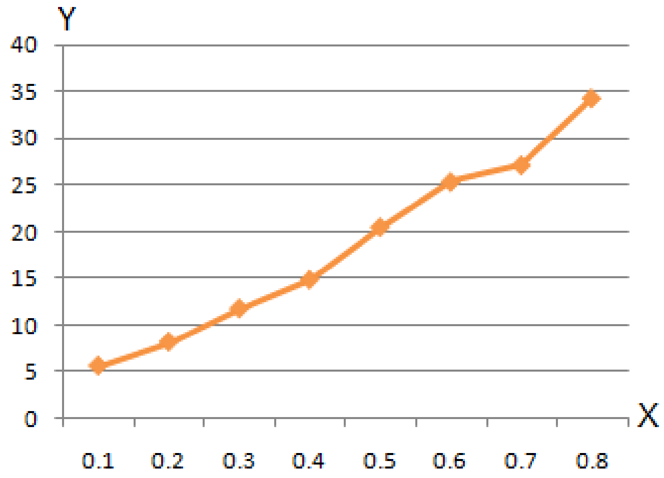
BRAKE TORQUE (N-M)



LOAD (KG)

Figure 12: graph of brake torque vs brake load
The brake torque increases with increase in brake load.

%DECLERATION

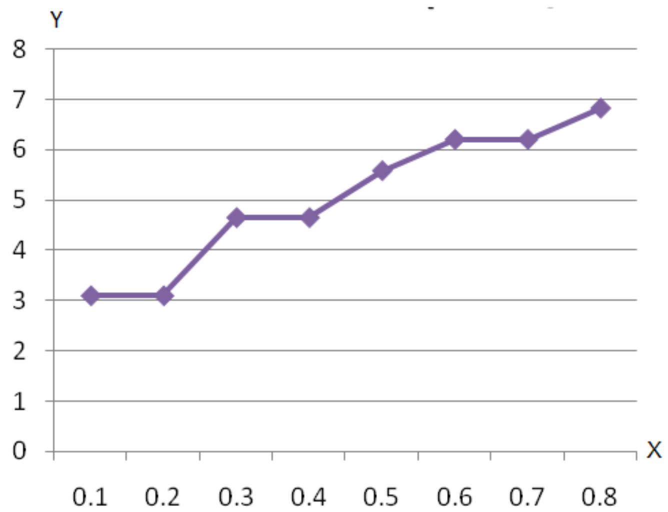


LOAD (KG)

Figure 13:graph of percentage deceleration vs brake load

The retardation / deceleration of drum increases with increase in brake load indicating the effectiveness of brake.

FADE VOLUME mm^3/10000 cycles



LOAD (KG)

Figure 14:graph of fade volume/ 10000 cycles vs brake load

The fade volume /10000 cycles is limited to 6.8 mm3 which is far less than the allowable value of 40 mm3 for the FTL-097 material indicating excellent brake performance against fade by virtue of application of discrete brake liner button geometry.

FINAL RESULT AND DISCUSSION:

1. As the Equivalent Von-misses stress 0.5839 N/mm^2 allowable stresses of 4 N/mm^2 the brake liner is safe.
2. As the maximum stress intensity 0.598 N/mm^2 allowable stress of 4 N/mm^2 the brake liner is safe. Thus analytical design of the brake liner button is safe.
3. Drum speed drops with increase in brake load
4. The brake torque increases with increase in brake load
5. The retardation / deceleration of drum increases with increase in brake load indicating the effectiveness of brake.
6. The fade volume /10000 cycles is limited to 6.8 mm^3 which is far less than the allowable value of 40 mm^3 for the FTL-097 material indicating excellent brake performance against fade by virtue of application of discrete brake liner button geometry.

FUTURE SCOPE

The discrete brake liner with buttons in the present model will be fitted with graphite inserts to test the performance and comparative analysis of both arrangements will be done as future work in project and recommendations for various applications will be done on the basis of data derived from test and comparison.

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