Design, Analysis and Comparative Experimental Performance Evaluation of Full Face and Staggered Liners in Band Brake

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Abstract- *Band brakes find application in industrial machines, material handling equipments like trolleys, cranes etc. and automobiles. The band brakes basically constitute of drum wound on periphery by a band, to which brake force is applied. Conventionally the band brake is made of single material like leather or asbestos, non-asbestos bands. With the advent of new materials with increased coefficient of friction, better wear resistance, the geometry of the band brake is also undergoing a change. Now days, the bands are liners with desired friction materials. Here we deals with one such application where band is lined with different friction linings on full face and broken (staggered) face. The objective is to carry out analysis of these brake liners using ANSYS and to study experimentally the performance of the full face liners and staggered liners under given system of loads to find out brake torque applied, percentage slip of the given brake liner..*

Keywords- Staggered liners, full face liners, copper wire embedded friction liners.

I. INTRODUCTION

The band brake friction materials play an important role in braking system. They convert the kinetic energy of a moving machine to thermal energy by friction during braking process. The ideal band brake friction material should have constant coefficient of friction under various operating conditions such as applied loads, temperature, speeds, mode of braking and in dry or wet conditions so as to maintain the braking characteristics of a machine. Besides it should also possess various desirable properties such as resistance to heat, water and oil, has low wear rate and high thermal stability, exhibits low noise, and does not damage the brake lining and disc. However, it is practically impossible to have all these desired properties.

Therefore, some requirements have to be compromised in order to achieve some other requirements. The friction and wear behaviour of automotive brake linings is complex and depends on their composition, temperature, rubbing speed, pressure, and most importantly the surface characteristics of the counter face.

With temperature the organic compounds disintegrate, friction decreases, and wear rate increases exponentially. This event is called fade. An ideal brake lining is the one which provides uniform and stable friction under all the operating conditions without any fade. The significance of friction material in material handling and earth moving machinery commonly used friction material earlier contained asbestos as the base material mainly because of its property to resist deformation under action of heat generated due to friction. This review focuses on analysis of the brake friction lining material and other materials for band brake application. Band brakes find application in braking in various fields of application such a material lifting applications lifts, cranes and hoist. Material transport equipment like conveyors, parachutes, trolleys etc.

Bouchetara Mustafa, Belhocine Ali.[1] Presented paper on Thermoelastic Analysis of Disk Brakes Rotor [1]. In this Paper the main purpose of this study is to analyze the thermo-mechanical behaviour of the dry contact between the brake disk and pads during the braking phase. K. Sowjanya & S. Suresh [2]Presented work on Structural analysis of disk brake rotor.Ali Belhocine, Mostefa Bouchetara[3]Presented paper on Thermo mechanical modeling of dry contacts in automotive disc brake. In this paper study is done to analyze the thermal behavior of the full and ventilated brake discs of the vehicles using computing code ANSYS. A.M. Zaharudina, R.J. Talib[4] Presented work on Taguchi method for optimizing the manufacturing parameters of friction materials. It presents a Semi-metallic friction materials were produced by the powder metallurgy method.M.A. Maleque, A. Atiqah [5] Presented paper on new natural fibre reinforced aluminium composite for automotive brake pad.In this paper is to develop new natural fibre reinforced aluminium composite for automotive brake pad application.

The proposed work include Design of critical components of the band brake using ANSYS .Design & analysis of band which is lined with woven friction lining on full face and broken (staggered) face. These linings will be tested on band brake setup will be tested to determine brake

torque applied, percentage drop in speed of the given brake liner.

II. DESIGN OF THE BAND BRAKE SYSTEM

The system is proposed to comprise of a single phase AC motor with variable speed coupled to an open belt drive that further drives a spur gear train which finally drives a drum on which the friction band will be operated for braking. The band will be selected with suitable friction lining material. The application of the braking force will be done using load arrangement. The assembly will be supported using a frame work mounted on the base plate.

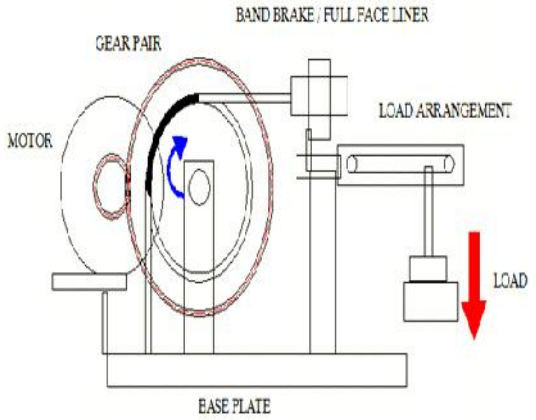

Fig.1 Details of the test rig set up

III. BRAKE FRICTION LINING MATERIALS

Following three materials are taken into consideration for study

FTL094 Material

Non-asbestos woven brake lining made of heat-resisting organic fiber and fine brass wire, impregnated with special resin binder. FTL094 is free from the particular prickliness of traditional non-Asbestos brake lining as it does not contain glass fibre at all. Color is brown

Fig.2 FTL094 material

FTL129 Material

FTL129 is a closely woven, semi-flexible friction material. It is based on yarn spun from a blend of glass and synthetic fibres together with a fine copper wire to enhance its strength and heat dissipation properties. The impregnant has been specially developed to give it good frictional properties combined with a good degree of flexibility. It has a high coefficient of friction and performs well in wet and damp environments which make it particularly suited for marine applications.

To help during fitting to brake shoes and bands it can be softened and made more pliable by warming in a bonding oven to between 150 & 180°C for sufficient time for the heat to penetrate the fabric.

Fig.3 FTL129 material

FTL095 material

Non-asbestos woven brake lining made of glass fiber yarn and fine brass wire, impregnated with special resin binder.Colour is yellowish. They are recommended for heavy duty applications due to its high tensile strength and longer durability.

Fig.4 FTL095 material

IV. FULL FACE LINERS IN BAND BRAKE SET-UP

Full Face Liners

The full face lining is a term used to define the liners that cover the entire span of angle of lap of the liner on the drum. Thus geometries is analysed using ANSYS to determine the strength of the liners.

Fig 5 Band with Full Face Liner

Cad Model for Full Face Liner

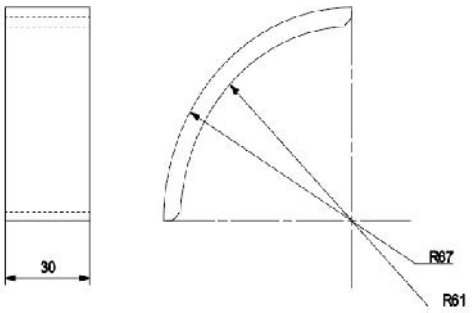

Fig. 6 2-D model of specimen using UG-NX 8.0

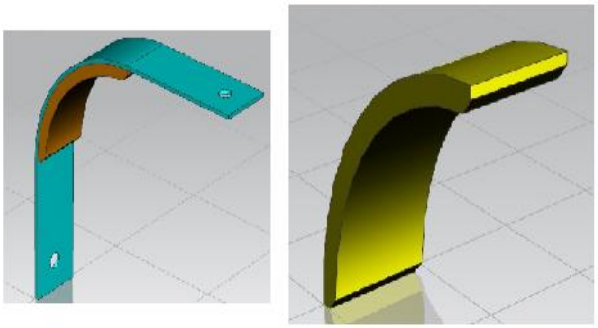

Fig.7 3-D model of specimen using UG-NX 8.0

The geometry of the full face liner was developed using UG-NX 8.0 and drafting was done using the drafting tool. The analysis of the above part is done using ANSYS Workbench 16.0. Geometry exported from UG-NX as a step file.

FEA Analysis of Full Face Liner

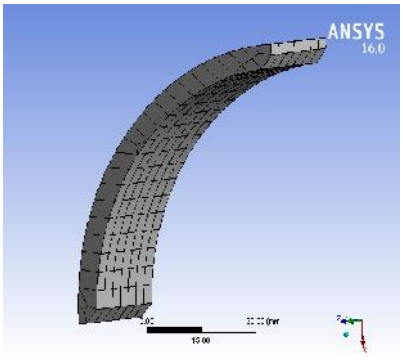

Fig.8 Meshed details of full face liners

Mesh details: Element type (tetrahedron), No of elements (203), No of nodes (1420)

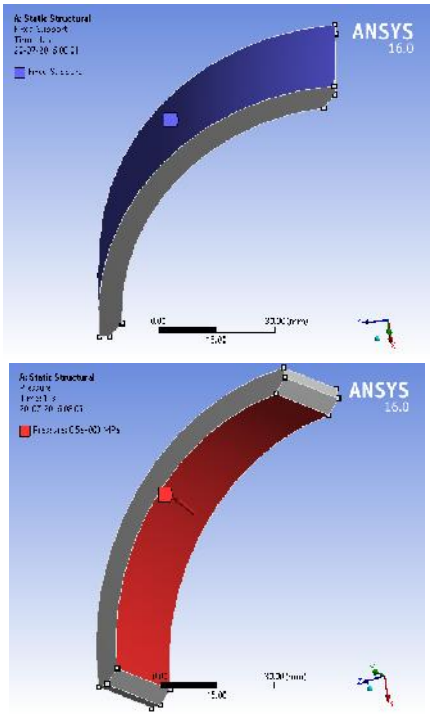

Fig.9 Boundary conditions for full face liner

Top surface of full face liner is fixed on to the band brake base and the bottom face is subject to maximum brake effort to stop the drum = 25.506 N, effort at which the drum stops rotation.

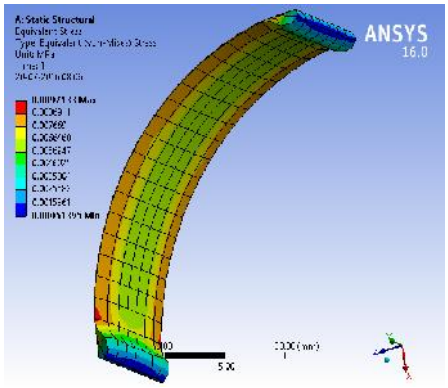

Fig.10 Equivalent Von-mises stress for full face liner

As the Equivalent Von-mises stress induced by application of maximum brake effort is 0.009713 N/mm2 < allowable stress of 19 N/mm2.

The full face liner is safe under given system of loads.

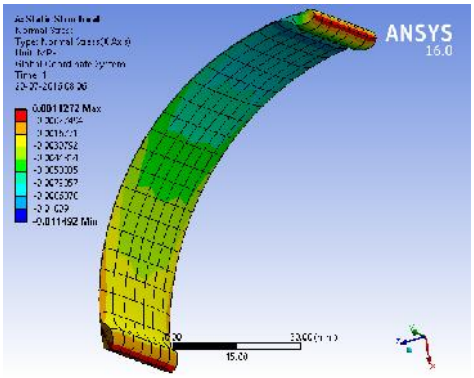

Fig.11 Normal stress for full face liner

As the Normal stress induced by application of maximum brake effort is 0.00112 N/mm2 < allowable stress of 8.5 N/mm2 the full face liner is safe under given system of loads.

The width of liner should be such as to cover at least 60 % of the drum width hence it is 30 mm and the thickness of the liner is determined by the manufacturer which is above 5 mm hence the design area under consideration in stress calculation will be on the higher side. Hence the actual value of stress will be low but the liner is needed to be thick for mounting purpose using screws therefore the stress values are justified.

STAGGERED LINERS IN BAND BRAKE SET-UP

Design and analysis of Staggered face liner i.e. liner will be provided in three segments over 92 degree angle of lap with each lap of 20 degree and spacing angle 16 degree, trial on the segmented band will be carried out to plot the performance characteristics similar to full face liner. Comparative analysis of Full face liner and segmented liner will be done. Recommendations regarding application of Full Face / Segmented liner will be done on the basis of comparative results.

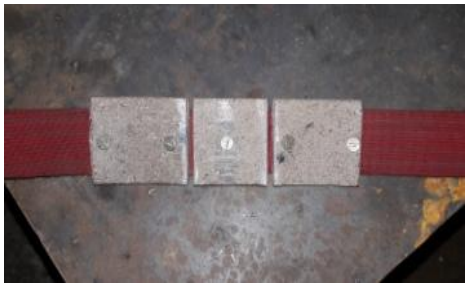

Fig.12 Band with Staggered Face Friction Liners

Cad Model for staggered liner

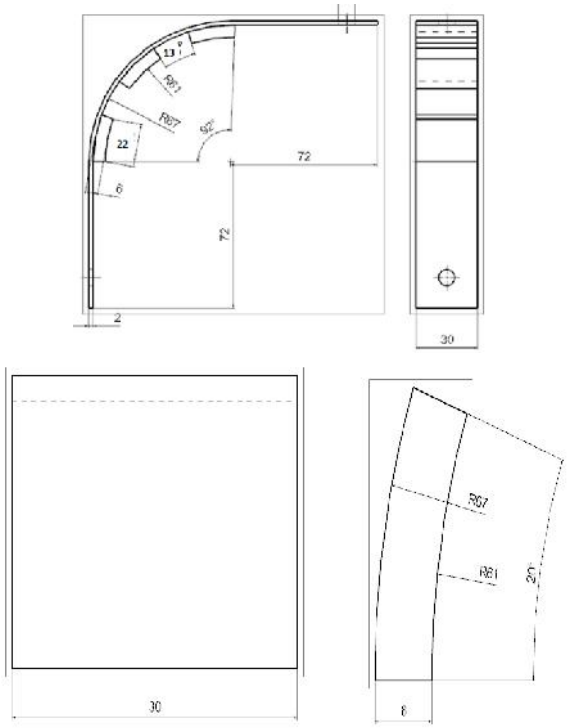

Fig.13 2-D model of specimen using UG-NX 8.0

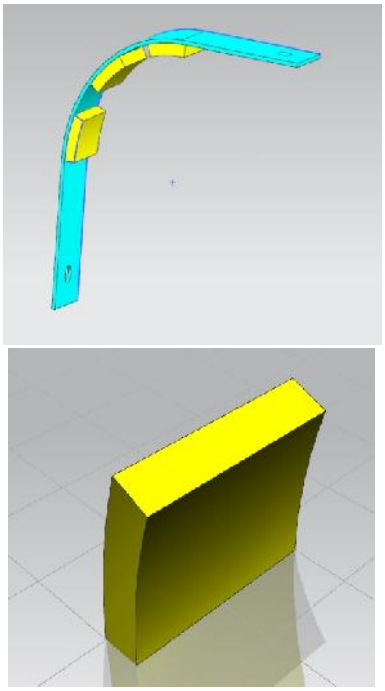

Fig.14 3-D Cad Model for staggered liner using UG-NX 8.0

FEA Analysis of Staggered Liner

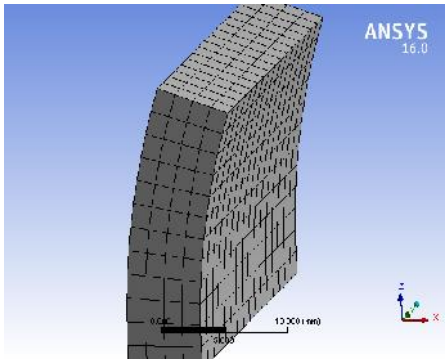

Fig.15 Meshed details of staggered liner

Mesh details: Element type (tetrahedron), No of elements (768), No of nodes (4049)

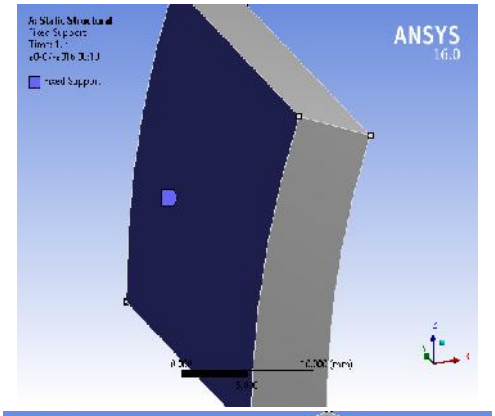

Fig.16 Boundary conditions for staggered liner

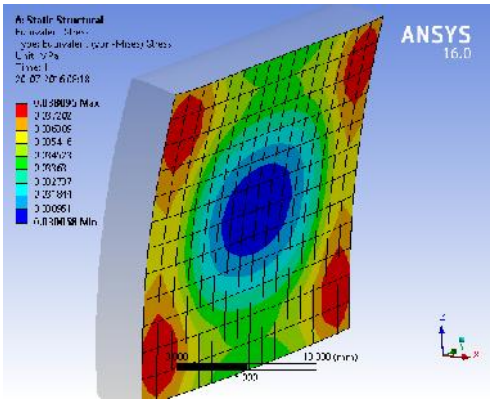

Fig.17 Equivalent Von-mises stress for full face liner

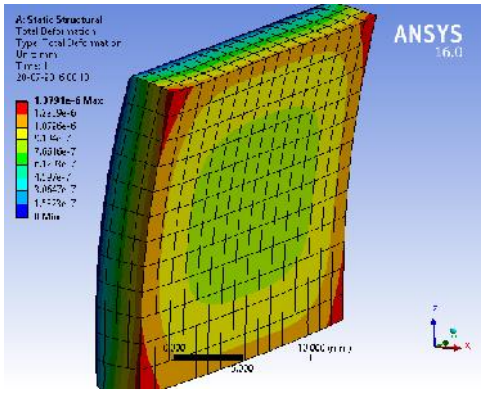

Fig.18 Total deformation for staggered liner

V. TEST AND TRIAL ON FULL FACE LINER & STAGGERED FACE LINER

Schematic of test rig used for Testing is as follows:

Fig.19 Experimental Test Set-up

Procedure

1) Start motor by turning electronic speed variator knob.
2) Let mechanism run & stabilize at certain speed
3) Place the pulley cord on dynobrake pulley and add 100 gm weight into, the pan , note down the output speed for this load by means of tachometer.
4) Add another 100 gm weight & take reading.
5) Tabulate the readings in the observation table

Plot Torque Vs speed characteristic, Power Vs speed characteristics.

Specifications

No load speed = 230 rpm
Drum diameter = 122 mm
Torque = W x r
Where r= Radius of drum = 61 mm

Observation table

Following observations are taken from above Experimental set-up

FTL095 material

Table No.1 Observation Table of FTL095 material for Full Face Linings

Load (kg)	Speed (rpm)	Brake Effort Torque (N-m)	Power Available after braking (watt)	% Drop In Speed
0.1	221	0.059841	1.385	3.91
0.2	212	0.119682	2.6573	4.07
0.3	199	0.179523	3.7416	6.17
0.4	179	0.239364	4.4874	10.05
0.5	151	0.299205	4.7318	15.64

FTL095 material

Table No.2 Observation Table of FTL095 material for Staggered Linings

Load (kg)	Speed (rpm)	Brake Effort Torque (N-m)	Power Available after braking (watt)	% Drop In Speed
0.1	212	0.059841	1.3287	7.82
0.2	195	0.119682	2.4443	8.02
0.3	176	0.179523	3.3092	9.74
0.4	156	0.239364	3.9108	11.36
0.5	131	0.299205	4.1051	16.02

VI. PERFORMANCE COMPARISON OF FULL FACE LINER AND STAGGERED LINER WITH FTL095 MATERIAL

The base material of the liner in both the cases is a cotton fiber belt lined with polyeurathane.This base material is merely the carrier the entire brake force is applied to the drum by means of the liner hence the liners are subjected to the complete wear and tear when in braking action. The full face lining is a term used to define the liner that cover the entire span of angle of lap of the liner on the drum where as the staggered liner is one that divides the angle of lap into three equally space section where in the brake force is applied collectively by the three elements. So the individual liners are subjected to 1/3rd load of the entire brake effort applied.

By studying all results it is observed that FTL095 materials shows better result in both Full Face and Staggered liners as compare to FTL094,FTL129 materials. So here FTL095 material is consider for comparison of performance of Full Face lining & staggered lining.

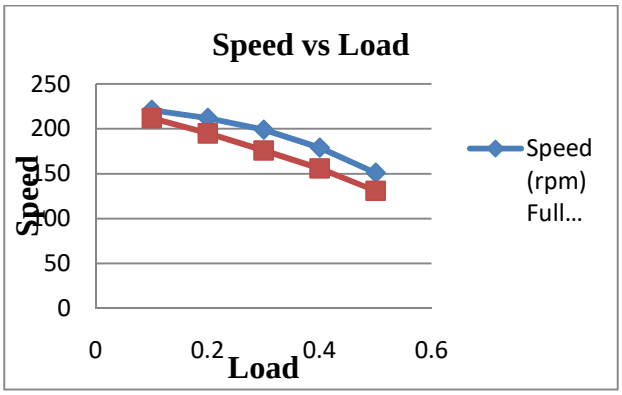

Fig.20 Graph of Speed vs Load

With staggered friction liners upto 13.24% speed reduction is obtained with compare to Full Face Liners.

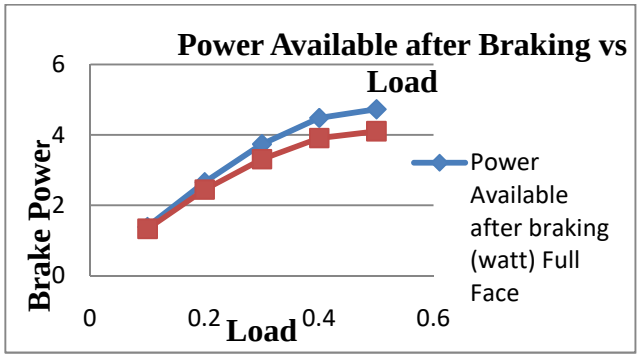

Fig.21 Graph of Power available after braking vs Load

Power available after braking is less in case of staggered liners as compare to full face liners i.e. brake power absorbed is more in case of staggered liners. Which results into better braking effect.

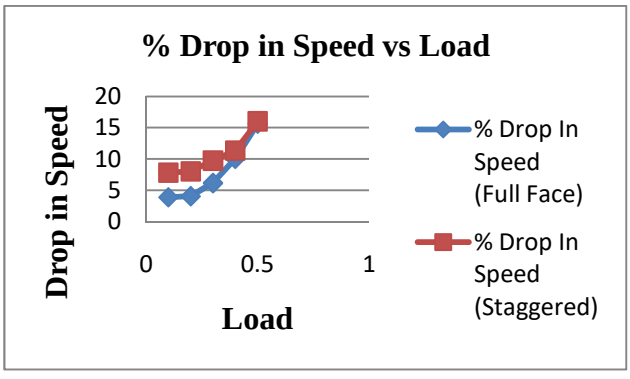

Fig.22 7.3 % Drop in Speed vs Load

It is observed that in case of staggered face lining value of % drop in speed is greater than full face lining. Upto 13.24 % drop in speed is observed.

VII. THEORETICAL VALIDATION

At 0.5 Kg Load

Experimental power = 4.10 watt

Where as theoretical power = 2 xπ xN xT /60

Where T= μRn x R = 0.6 x 0.5 x9.81x 0.061 = 0.179523

Theoretical Power = (2 xπ xN xT /60) / efficiency of power transmission upto drum

= (2 xπ x 131 x 0.179523 /60) /0.65 = 3.7888 watt

Theoretical power= 3.7888 watt

It can be seen that the theoretical and experimental power are closely matching.

VIII. CONCLUSION

1. Here three different friction lining materials FTL 095, FTL129 and FTL094 are tested for both full face and staggered liners. After testing it is observed that FTL095 shows better speed reduction and better power absorption.
2. When brake is applied with full face liner, whole surface of brake liner is in contact with drum. High Heat generated while braking but this heat generated is not released as there is no provision.
3. In case of staggered face liners due to the gap between two blocks of friction lining used more space is available for heat dissipation. This improves the performance of braking system. So staggered face liners shows better performance as compare to full face liners. Cost of staggered face liners is less as less material is used.
4. With staggered friction liners upto 13.24% speed reduction is obtained with compare to Full Face Liners
5. Power available after braking is less in case of staggered liners as compare to full face liners i.e. brake power absorbed is more in case of staggered liners. Which results into better braking effect.
6. It is observed that in case of staggered face lining value of % drop in speed is greater than full face lining. Up to 13.24 % drop in speed is observed.
7. Experimental results are validated with theoretical.

APPENDIX

Journal Paper submitted

Anuradha Zende, Prof. Amol Kokare, “Design, analysis and testing on Full face copper wire embedded liners in band brakes”, PGCON (2016).

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