International Journal of Emerging Engineering Research and Technology
Volume 2, Issue 8, November 2014, PP 116-122
ISSN 2349-4395 (Print) & ISSN 2349-4409 (Online)

A Review Paper on Composite Brake Friction Lining for lining Applications on Band Brake

Priyanka S. Bankar
ME Student
Department of Mechanical Engineering
Rajarshi Shahu COE
Pune
priya2020bankar@gmail.com

S. N. Khan
Assistant Professor
Department of Mechanical Engineering
Rajarshi Shahu COE, Savitribai Phule Pune University, Pune (India)
subim_khan@yahoo.com

Abstract: *In this paper, Woven brake linings are designed for all types of brakes and drum clutches in most critical applications. They feature high and stable friction coefficient and guarantee meeting the strictest safety requirements as their design assures resistance to rapid failures. Woven friction linings are difficult to mould and it is difficult to incorporate any inserts in the lining that are used in lifting machine applications where high temperature and high pressure conditions are common. In such cases it is recommended to use the pressed linings. Thus it is proposed to develop composite lining in curved geometry with Fibre reinforced asbestos and Reybestos or commercial name Ferodo as base material and graphite insert material. It is expected that such linings are based on highly durable and heat resistance to temperature, featuring high friction coefficient of friction ad high durability. Paper includes investigators work done on analysis design was analyzed considering the different parameters. This review can help analysts to choose right methods and make decisions on new areas of method development.*

Keywords: *Composite materials, Brake Friction linings, Band brake, Wear Analysis.*

1. 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. In general, each formulation of friction material has its own unique frictional behaviours and wear-resistance characteristics. Frictional material used in band brake pads is made up of four subcomponents which play different roles. These are; abrasives materials to modify friction, lubricants to stabilize developed friction, binders to hold different constituents together and prevent disintegration and fillers to improve manufacturability as well as lower the cost. Band brake lining pads and disc are required to maintain; a sufficiently high friction coefficient with the band brake lining, not decompose or break down at high temperatures and exhibit a stable and consistent friction coefficient. The friction and wear behavior 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 [2].

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 [4]. 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.

2. OBJECTIVE OF RESEARCH

The objective of the Research Project is to:

- Mathematical modeling for geometry of brake lining for band brake arrangement.
- 3D-Modelling & analysis of plain & composite brake lining ANSYS software.
- Test & trial on individual brake lining in plain & composite condition to determine absorbed in friction wear rate; Heat dissipation ability & optimal hardening.

3. BASIC THEORY

3.1. Crane Trolley Braking Torque

Crane trolley brakes are typically sized with a torque rating less than the motor's full loads torque (service factor less than 1.0) to provide a longer stopping time or a soft stop. Overhead crane trolley brakes are minimized to prevent sway of the hook and load.

Typical service factor is 50% for soft stopping.

3.2. Selecting Brake Size Based on Load Data

For applications where high inertial loads exist or where a specific stopping time or distance is required, the brake should be selected based on the total inertia of the load. Total system inertia reflected to the brake shaft can be expressed as follows:

WK_T^2 Where:	=	$WKB^2 + WK_M^2 + WK_L^2$
WK_T^2	=	Total reflected inertia to brake.
WK_B^2	=	Inertia of brake wheel.
WK_M^2	=	Inertia of motor rotor.
WK_L^2	=	Equivalent inertia of load reflected to brake shaft.

4. DESIGN CHALLENGES

4.1. Design Challenges1

A 3-D finite element analysis is built using ANSYS-14.0 version software into consideration for static and Wear analysis on the Composite Brake Lining Materials.

4.2. Design Challenges2

A graphical analysis is present to find out optimum fiber orientation for given Composite Brake Lining Materials with different layer.

4.3. Design Challenges3

Comparisons are made for two different approaches-

- The Finite Element Model
- The Theoretical Model.

5. LITERATURE REVIEW

A. K. Sowjanya & S. Suresh (2013), Presented paper on Structural analysis of disk brake rotor [1]. This paper Disc brake is usually made of Cast iron, so it is being selected for investigating the effect of strength variations on the predicted stress distributions. Aluminum Metal Matrix Composite materials are selected and analyzed. The domain is considered as axis-symmetric, inertia and body force effects are negligible during the analysis. The model of Disc brake is developed by using Solid modeling software Pro/E (Cero-Parametric 1.0).Further Static Analysis is done by using ANSYS Workbench. Thermal solution to the structural analysis and the maximum Von Misses stress was observed to be 50.334 M Pa for CI, 211.98 M Pa for AlMMC1, and 566.7 M Pa for AlMMC2, the Brake disc design is safe based on the Strength and Rigidity Criteria.

B. A.M. Zaharudina, R.J. Talib (2012) Presented paper on Taguchi method for optimizing the manufacturing parameters of friction materials [2]. This paper presents a Semi-metallic friction

materials were produced by the powder metallurgy method. This study investigated the optimization of manufacturing parameters (moulding pressure, moulding temperature and moulding time) for friction materials using the Taguchi Method. Physical properties (hardness and specific gravity) and tribological properties (wear and fade) were selected as the quality target. It was determined that moulding pressure has the strongest effect on physical and tribological properties. It was observed that friction materials with the optimal level of parameters proved to be the best performer in tribological characteristic.

C. *M.A. Maleque, A. Atiqah (2012)* Presented paper on New natural fibre reinforced aluminium composite for automotive brake pad [3]. In this paper is to develop new natural fibre reinforced aluminium composite for automotive brake pad application. Four different laboratory formulations were prepared with varying coconut fibre contents from 0, 5, 10 and 15 volume fraction along with binder, friction modifiers, abrasive material and solid lubricant using powder metallurgy technique for the development of new natural fibre reinforced aluminium composites. The properties examined are density, porosity, microstructural analysis, hardness and mechanical properties using densometer, SEM, hardness tester and universal testing machine. The better properties in terms of higher density, lower porosity and higher compressive strength were obtained from 5 and 10% coconut fiber composites. The microstructure reveals uniform distribution of resin and coconut fibre in the matrix. It can be concluded that 5 and 10% showed better physico-mechanical properties compared to other formulations. Hence, natural coconut fibre is a potential candidate fiber or filler material for the automotive brake pad material.

D. *Masahiro Kubota (2000),* Presented paper on Development of lightweight brake disc rotor: A design approach for achieving an optimum thermal, vibration and weight balance. Presented [4]. This Paper presents development of a lightweight brake disc rotor: a design approach for achieving an optimum thermal, vibration and weight balance. This paper presents a parametric study that was conducted on the basis of an analysis of airflow through the ventilation holes as well as a thermal stress analysis and a vibration analysis during braking. Based on the relationships obtained between rotor weight, shape and each performance requirement, a method is presented for designing a lightweight disc rotor. Computational fluid dynamics (CFD) analysis approach is used to visualize the actual process. Short and gourd shaped fins arrangement had been used and the results verified that anti-squeal performance was improved, and also a substantial weight reduction was achieved compared with the baseline rotor shape without causing cooling performance and heat resistance to deteriorate.

E. *Bouchetara Mostefa, Belhocine Ali (2014)* Presented paper on Thermo elastic Analysis of Disk Brakes Rotor [5]. In this Paper the main purpose of this study is to analyze the thermo-mechanical behavior of the dry contact between the brake disk and pads during the braking phase. The simulation strategy is based on computer code ANSYS11. The modeling of transient temperature in the disk is actually used to identify the factor of geometric design of the disk to install the ventilation system in vehicles The thermal-structural analysis is then used with coupling to determine the deformation and the Von-Mises stress established in the disk, the contact pressure distribution in pads. The results are satisfactory when compared to those of the specialized literature.

F. *Ji-Hoon, Choi and Lee (2004)* presented a paper on Finite element analysis of transient thermo elastic behaviors in disk brakes [6]. In this paper a transient analysis for thermo elastic contact problem of disk brakes with frictional heat generation is performed using the finite element method. To analyze the thermo elastic phenomenon occurring in disk brakes, the coupled heat conduction and elastic equations (Cylindrical coordinates) are solved with contact problem. Material used is carbon, carbon composite and wear is assumed negligible. The numerical simulation for the thermo elastic behavior of disk brake is obtained in the repeated brake condition. The computational results are presented for the distributions of pressure and temperature on each friction surface between the contacting bodies. It is observed that the orthotropic disc brakes can provide better brake performance than the isotropic one because of uniform and mild pressure distribution.

G. *Oder G. (2009)* presented a paper on Thermal and stress analysis of brake discs in railway vehicles [7]. This paper present work on thermal and stress analysis of brake discs in railway vehicles. Performed analysis deals with two cases of braking; the first case considers braking to a standstill;

the second case considers braking on a hill and maintaining a constant speed. In both cases the main boundary condition is the heat flux on the braking surfaces and the holding force of the brake calipers. In addition the centrifugal load is considered. Finite element method (FEM) approach is been used, 3D model has been modeled for analysis. Brake disc material is rounded graphite; two types of disc considered for studies one without wear and one with 7 mm wear on both sides. Maximum speed is 250 km/hr and the ambient and initial disc and surrounding temperature is 50°C Temperatures and stress in discs under different loads is very high. Although they are fulfilling the buyer's requirements for safety, this investigation not considered shearing forces, residual stress and the cyclic loads during brake discs lifespan. The results need to be compared with experimental results.

H. Zaid (2009) presented a paper on an investigation of disc brake rotor by Finite element analysis [8]. In this paper, the author has conducted a study on ventilated disc brake rotor of normal passenger vehicle with full load of capacity. The study is more likely concern of heat and temperature distribution on disc brake rotor. In this study, finite element analysis approached has been conducted in order to identify the temperature distributions and behaviors of disc brake rotor in transient response. Modeling is done in CATIA & ABAQUS/CAE has been used as finite elements software to perform the thermal analysis on transient response. Material used is Grey cast iron, with maximum permissible temperature 550 C. For load analysis 10 cycles of breaking and 10 cycles without breaking (idle) operation is considered total of 350 seconds. Result provided during 1st , 5th and during 10th cycle. Thus, this sure study provide better understanding on the thermal characteristic of disc brake rotor and assist the automotive industry in developing optimum and effective disc brake rotor.

I. *Malcolm K. Stanford (2001)* Presented paper on Friction and wear characteristics of hard coatings [9]. The friction and wear behavior of four hard coatings was determined using a pin-on-disk machine. The coatings were thermal sprayed on cast iron disks. The coating compositions were Ni–17Cr–2.5Fe–2.5Si–2.5B–0.15C (Metco), Sliding was performed between cylindrical pins machined from non-asbestos organic (NAO) brake lining and the coated and uncoated disks. The lining, consisting of resin, Aramid pulp, zirconium, graphite, calcium fluoride, rubber and barium sulfate, was developed as a material for automotive brake pads. The coatings were characterized by measuring their hardness, porosity, and corrosion resistance. The corrosion resistance of the coatings was tested with exposure to 5% NaCl for 168 h. The Stellite coating had the best corrosion resistance. The friction and wear tests were conducted at contact pressures of 1.72, 3.45 and 6.89MPa and sliding speeds of 1 and 3m/s. The wear of the lining material was lowest when it slid against the Stellite coated disks and the highest coefficient of friction was observed for the Metco coated disks.

J. *W.O. sterle, H. Klob (2007)* towards a better understanding of brake friction materials [10]. This work focuses by on surface changes induced by repeated brake applications and tries to provide explanations, how such material modifications might affect friction and wear properties of automotive disc brakes. Surface films were investigated locally by transmission electron microscopy (TEM) after having prepared thin cross-sections with a focused ion beam instrument (FIB). Since the observed friction layers revealed a nano-crystalline structure, modeling with the method of movable cellular automata (MCA) was performed by assuming an array of linked nanometer-sized particles.

K. *Dr. S. B. Chikalthankar, Dr. V. M. Nandedkar (2013)* this paper presents on a Review & Literature of Frictional & Wear Characteristics of Non-Asbestos Brake Pad Using Link Chase Machine [11]. The frictional and wear characteristics of non-asbestos brake pad were studied using link chase machine. The chase machine is used to perform the test as per SAE J661.The coefficient of friction and wear is an important performance measure in this process. Since long, researchers have explored a number of ways to improve and stable the coefficient of friction and wear rate which is similar to the asbestos material. A large range of different non-asbestos materials are studied by different researchers; all the research work in this area shares the same objectives of achieving the same performance from non-asbestos material as that of asbestos material. The paper reports research on relating to improve and stable the coefficient of friction and wear rate in the end of the paper scope for future research work has been outlined.

6. STRESS ANALYSIS AND BOUNDARY CONDITIONS

In the according to anchoring condition the chain wheel of the achoe windless should brake reliable. When the chain wheel revolves in clockwise direction with angular velocity the rod tension F (instantaneous tension of rod) tightens the brake band to hug the brake drum. That means the friction between the brake band and the brake drum (friction material is non asbestos organic friction material) plays the braking role. We are going to further analysis and Proposed Setup for analysis of Band Brake as shown in below Fig.1

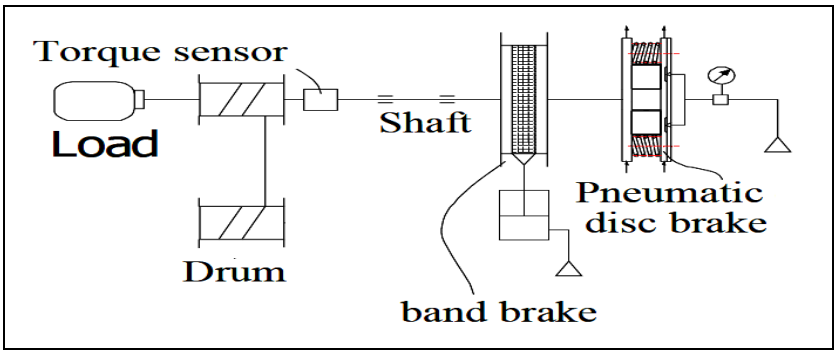

Figure1. *Proposed Setup for analysis of Band Brake*

Fig.2 shows a flexible band with equal thickness on the outer surface of the cylindrical wheel, with thickness h and width b. Assuming the mass per unit area of the band is $m=\rho h$; cylindrical wheel rotation at both end of the band are respectively F_1 F_2. There are 3 unit forces on the band, which are wheel cylinder pressure P varying with the angle θ unit friction F_f and Uniform distribution centrifugal force Pc.

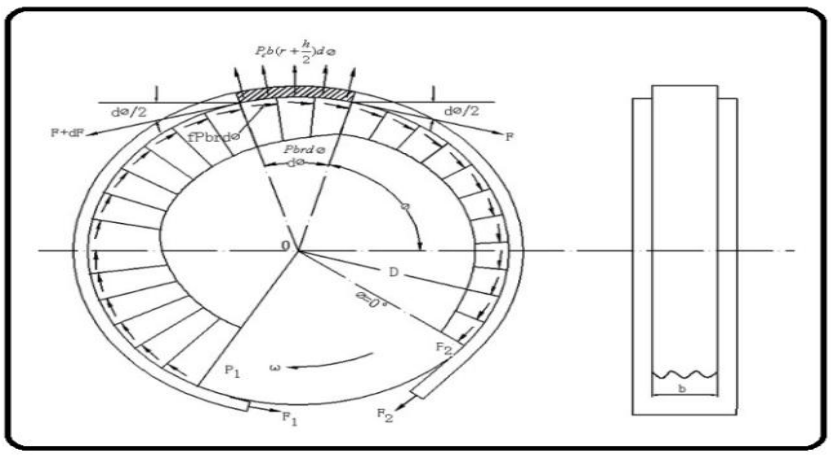

Figure2. *Stress analysis of the flexible body*

According to the force balance principles, the relations between these forces in y direction can be expressed as:

$$F_P + F_V - F\sin\frac{d\phi}{2} - (F+dF)\sin\frac{d\phi}{2} = 0 \tag{1}$$

That is,

$$Pbrd\varphi + P_c b(r+\frac{h}{2})d\varphi - F\sin\frac{d\varphi}{2} - (F+dF)\sin\frac{d\varphi}{2} = 0 \tag{2}$$

When the anchor chain driven by the rated load, the boundary condition can be determined by solving the above formula, Details are shown in fig.2

7. MATERIAL SELECTION OF BRAKE LINING MATERIAL FOR BAND BRAKE

It can be seen that friction coefficient and wear resistance have the highest weighting factors followed by thermal capacity, whereas the least important properties are compressive strength and specific

gravity hence, obtained lower weighting factor.

The assumptions which are made while selection the process is given below:

- The domain is considered as axis-symmetric.
- Inertia and body force effects are negligible during the analysis.
- The band brake is stress free before the application of brake.
- The analysis is based on pure thermal load and pressure load.
- The specific heat of the material used is constant throughout and does not change with temperature.

A material collection with less cost and a real time model with the assumed dimensions and testing of the model. There is also scope of research in improvement of heat transfer of band by increasing the contact time between band material and air flow by design modification of band layer in such a way that fulfills the requirement.

8. FUTURE SCOPE

The scope of research will include developing mathematical model for profile and shaping development of the lining so as to determine geometrical dimensions of lining to absorb determined brake power.

Woven friction linings are difficult to mould and it is difficult to incorporate any inserts in the lining that are used in lifting machine applications where high temperature and high pressure conditions are common. In such cases it is recommended to use the pressed linings. Thus it is proposed to develop composite lining in curved geometry with Fibre reinforced asbestos and Reybestos or commercial name Ferodo as base material and graphite insert material.

9. CONCLUSION

This paper is review about the various engineering aspects of the composite brake lining materials considering their nature, behaviour and properties. To achieve ideal brake friction material characteristic such as a constant coefficient of friction under various operating conditions, resistance to heat, low wear rate. This can be done by changing the material type and weight percentage of the ingredients in the formulation. So from above we can conclude that research on a composite brake lining with graphite material can be used in band brake which will give moderate cooling at low temperature.

ACKNOWLEDGMENT

I gratefully acknowledge Mechanical engineering department of RSCOE, Pune for technical support and providing the research facilities. I would also like to thank to Dr. D. S. Bormane, Principal (RSCOE, Pune) and Prof. A. A. Pawar, HOD (Mechanical department) for their help and dedication toward my research and related research, also my friends for their directly & indirectly help, support and excellent co-operation.

REFERENCES

[1] K. Sowjanya, Structural analysis of disk brake rotor, *International Journal of compute trends and technology, July 2013;4(7)*

[2] A.M. Zaharudina, R.J. Talib, Taguchi method for optimizing the manufacturing parameters of friction materials, *International Journal of Mechanical and Materials Engineering, Vol. 7 2012; 7(1) :83–88.*

[3] M.A. Maleque, A. Atiqah, New natural fibre reinforced aluminium composite for automotive brake pad, *International journal of mechanical and materials engineering, 2012; 7(2):166-170.*

[4] Masahiro Kubota, Development of lightweight brake disc rotor: A design approach for achieving an optimum thermal, vibration and weight balance, *JASE review 2000; 21:349-355.*

[5] Bouchetara Mostefa, Belhocine Ali, Thermo elastic Analysis of Disk Brakes Rotor, *American Journal of Mechanical Engineering, 2014; 2(4):103-113.*

[6] Ji-Hoon Chio, Finite element Analysis of transient thermo elastic-behaviors in disk brakes, *Wear, 2004; 257:47-58.*

[7] Oder G, Thermal and stress analysis of brake discs in railway vehicles, *Advance Engineering 2009; 3.*

[8] Ziad, An investigation of disc brake rotor by FEA, *Wear 2009; (3)2*

[9] Malcolm K. Stanford. Friction and wear characteristics of hard coatings, *Wear 2001; 251: 990–996.*

[10] W.O.sterle, H. Klob. Towards a better understanding of brake friction materials, *Wear. 2007; 263: 1189–12*

[11] Dr. S. B. Chikalthankar, Dr.V.M. Nandedkar, A Review & Literature Of Frictional & Wear Characteristics Of Non-Asbestos Brake Pad Using Link Chase Machine, *International Journal of Mechanical Engineering and Technology (IJMET), 2014; 5(1): 140-145.*

[12] K. M. Muniswamy, Heat transfer enhancement on ventilated brake disk with blade inclination angle variation, *International journal of automotive technology, 2013;14(4):569-577.*

[13] J.M. Herring, Mechanism of Brake Fade in Organic Brake Pad Linings, *Society of Automotive Engineers Transaction. 1967; 1:670-146.*

[14] B.J. Briscoe, I. Ramirez, P.J. Tweedle, Friction of aramid fibre composites, in: Proceedings of the International Conference on Disc Brakes for Commercial Vehicles, *The Institution of Mechanical Engineers(London UK). 1988; 1:15–29.*

[15] A.E. Anderson, Friction and wear of automotive brakes, in: ASM Handbook: Friction, Lubrication, and Wear Technology, *ASM International, Materials Park, OH, 1992; 18:569–577.*

AUTHORS' BIOGRAPHY

Ms. Priyanka S. Bankar, Currently pursuing M.E in Design Engineering *(Mechanical Engineering) Department of Mechanical Engineering,* Rajarshi Shahu College of Engineering, Tathawade, Pune, Savitribai Phule Pune University, Pune (India)

Prof. S. N. Khan, Currently working as an Assistant *professor, Department of Mechanical Engineering,* Rajarshi Shahu College of Engineering, Tathawade, Pune, Savitribai Phule Pune University, Pune (India)