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Experimental investigation & analysis of composite brake linings with graphite inserts for lifting machine applications

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ABSTRACT

This paper presents woven brake linings which are designed for band brakes in lifting machine applications. They feature high and stable friction coefficient. 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. The design has strictest safety requirements as design assures resistance to rapid failures. Thus for further better results, we develop composite lining in curved geometry with fiber reinforced asbestos and reybestos or commercial name Ferodo as base material and graphite inserted lining material. It is expected that such linings are based on highly durable and heat resistance to temperature, high coefficient of friction and high durability.

A 3D model of the test rig has been established. Temperature and strength analysis of individual linings in plain and composite insert form for both materials has been done using ANSYS software. Efforts have also been made to select the most appropriate design to be used for lifting machine applications based on the results obtained. All results can provide references for improving a design.

Keywords— Band brake, Composite materials, Brake Friction linings, Wear.

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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. In general, each formulation of friction material has its own unique frictional behaviors 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.

II. OBJECTIVES OF THE STUDY

The objective of the Research Project is to:

a) Mathematical modeling for geometry of brake lining for band brake arrangement.

b) 3D-Modelling & analysis of plain & composite brake lining ANSYS software.

c) 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

A. 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.

B. 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:

WKT2
Where, = WKB2 + WKM2 + WKL2

WKT2 = Total reflected inertia to brake.
WKB2 = Inertia of brake wheel.
WKM2 = Inertia of motor rotor.
WKL2 = Equivalent inertia of load reflected to brake shaft.

4. DESIGN CHALLENGES

A. Design Challenges 1:

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.

B. Design Challenges 2:

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

C. Design Challenges 3:

Comparisons are made for two different approaches-

1 The Finite Element Model
2 The Theoretical Model.

III. LITERATURE REVIEW

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.

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.

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.

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.

BouchetaraMostefa, 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.

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.

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. The results need to be compared with experimental results.

IV. 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

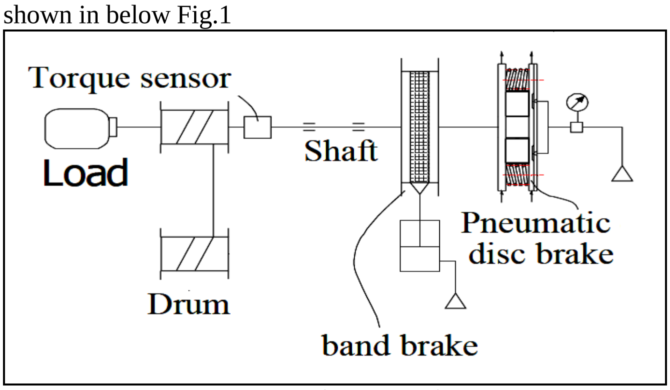


Figure-1. Proposed Setup for analysis of Band Brake

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=ρh; cylindrical wheel rotation at both end of the band are respectively F1 F2. There are 3 unit forces on the band, which are wheel cylinder pressure P varying with the angle θ unit friction Ff and Uniform distribution centrifugal force Pc.

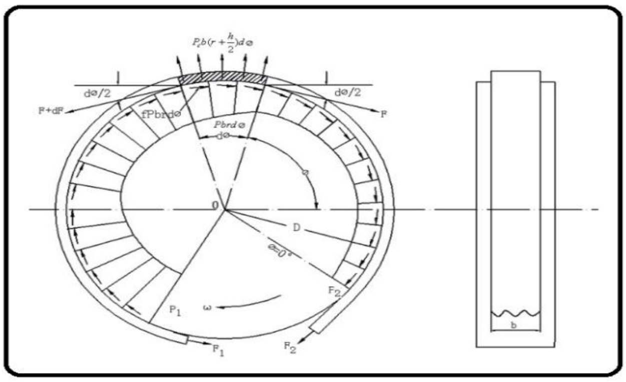
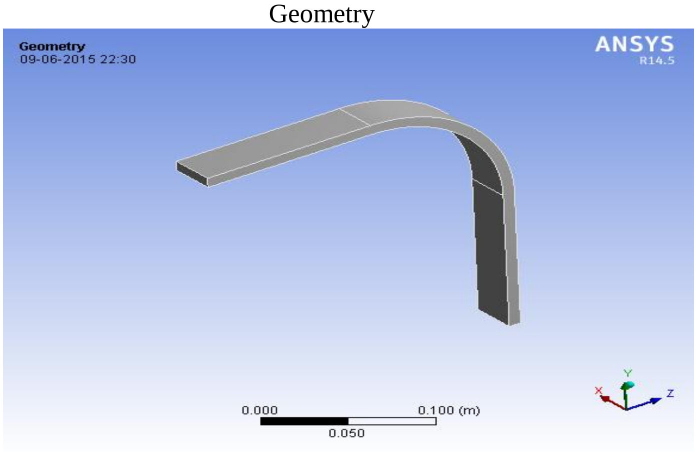


Figure-2. Stress analysis of the flexible body

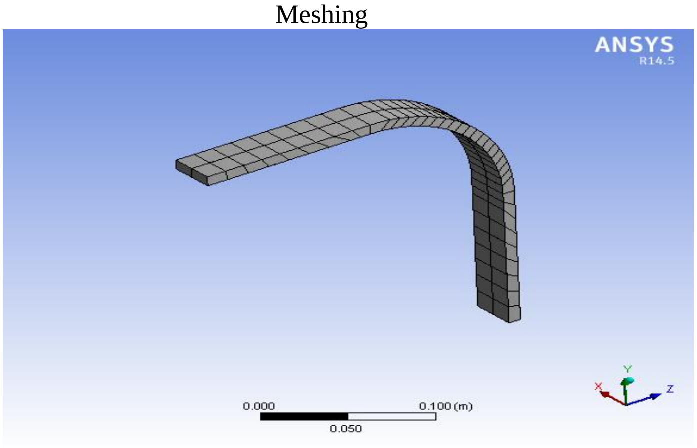
When the anchor chain driven by the rated load, the boundary condition can be determined by solving the above formula, Details are shown in fig.2

Tensile strength = 1900 N/cm2

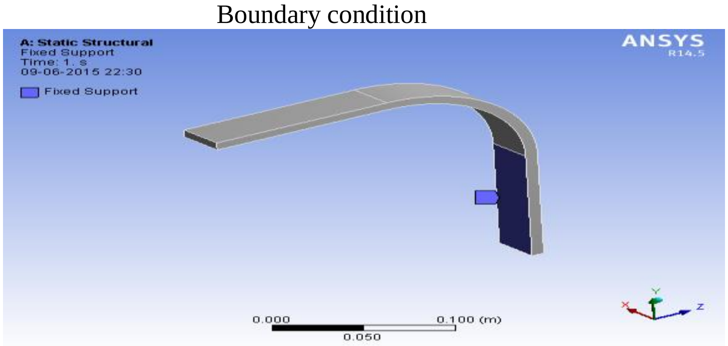
Geometry



Meshing



Boundary condition



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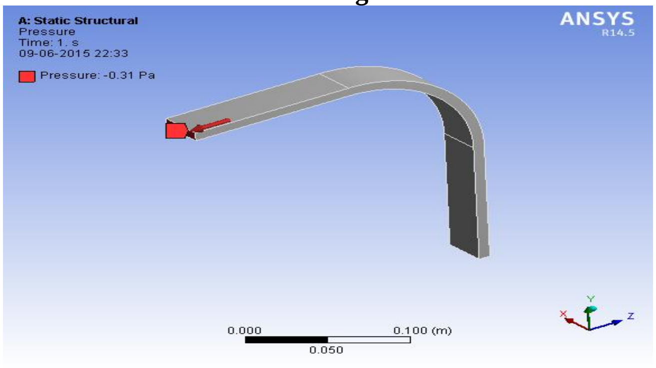
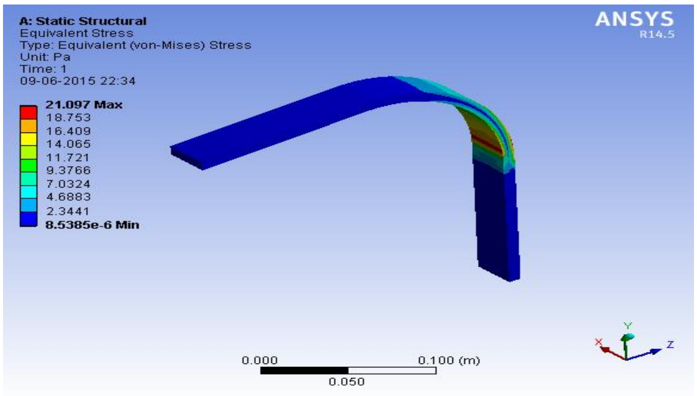
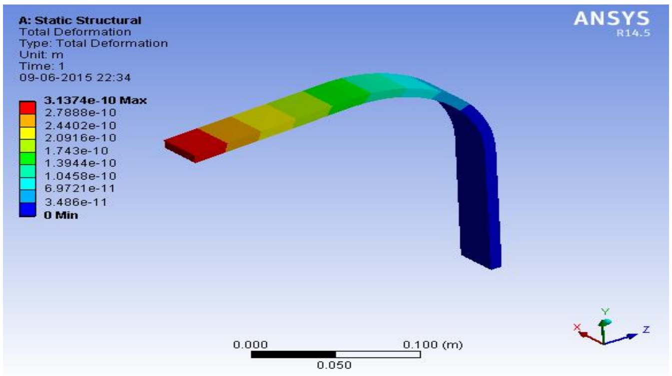
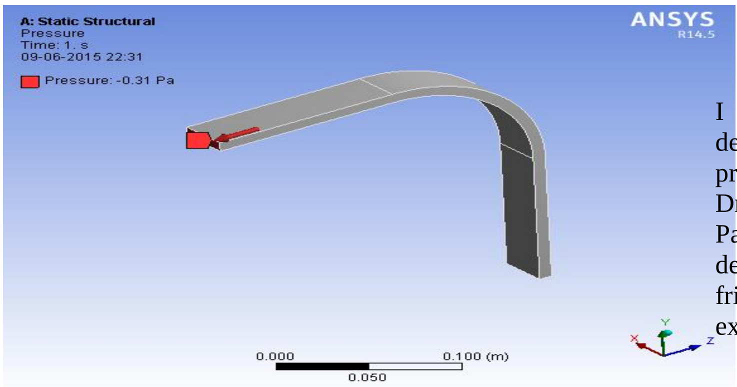
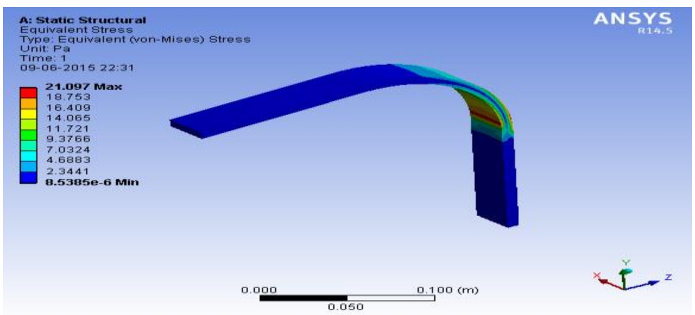


Result









V. RESULT & DISCUSSION

Part Name	Equivalent Von-mises Stress N/cm2	Maximum deformation mm	Result
BAND FTL-095	219.7	3.1x 10-8	Safe

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.

VI. CONCLUSIONS

This paper is 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 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 result at low temperature.

1. The results suggest that the maximum stress induced in the band due to system of forces are well below the allowable stress (1900N/cm2)
2. Total deformation is negligible hence the design of the band is safe.

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