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Structural Analysis of Dual Brake System

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With the increasing technological development in the area of motors, heavy–duty vehicles have been suffering an increase in size and in load capacity. Friction brakes are to decelerate a vehicle by transforming the kinetic energy of the Vehicle to heat, via friction, and dissipating vibration that heat to the surroundings, which produces excessive heat on lining surface. This shows increase in frictional area will definitely reduce the load on brakes by sharing the energy of the vehicle. So the above- factor is taken into account and finally reduction in inertia forces on rotating shaft by providing more frictional area is discussed on this paper. Also give details about applying the frictional force on differential gear shaft. To achieve this inner shoe, which is less than the size of the outer shoe, is provided as per the design of the system developed with the aid of solid works modeling tool. This can be actuated by a specially designed cam, which will actuate both outer shoe and inner shoe respectively. During braking the outer shoe will engage previously to absorb energy in the drum before the inner shoe get actuated. When the cam moves both the shoe remaining energy in both shoes share the vehicles. This entire system is analyzed by using FEA tool ANSYS 14.0 to determine the thermal stress developed in it. These results are compared with the conventional braking system.

Keywords: dual brake, structural analysis, generative model.

1. Introduction

A brake is a device by means of which artificial frictional resistance is applied to moving machine member, in order to stop the motion of a machine.

In the process of performing this function, the brakes absorb either kinetic energy of the moving member or the potential energy given up by objects being lowered by hoists, elevators etc. The energy absorbed by brakes is dissipated in the form of heat. This heat is dissipated in the surrounding atmosphere to stop the vehicle, so the brake system should have following requirements:

1. The brakes must be strong enough to stop the vehicle with in a minimum distance in an emergency.
2. The driver must have proper control over the vehicle during braking and vehicle must not skid.
3. The brakes must have well anti fade characteristics i.e. their effectiveness should not decrease with constant prolonged application.
4. The brakes should have well anti wear properties.

2. Dual brake

A Dual brake consists of a cast iron Dual bolted to the wheel hub and a stationary housing called caliper. The caliper is connected to some stationary part of the vehicle like the axle casing or the stub axle as is cast in two parts each part containing a piston. In between each piston and the Dual there is a friction pad held in position by retaining pins, spring plates etc. passages are drilled in the caliper for the fluid to enter or leave each housing. The passages are also connected to another one for bleeding. Each cylinder contains rubber-sealing ring between the cylinder and piston.
The main components of the Dual brake are:

1. The Brake Pads.
2. The Caliper which contains the piston.
3. The Rotor, which is mounted to the hub.

When the brakes are applied, hydraulically actuated pistons move the friction pads in to contact with the rotating Dual, applying equal and opposite forces on the Dual. Due to the friction in between Dual and pad surfaces, the kinetic energy of the rotating wheel are converted into heat, by which vehicle is to stop after a certain distance. On releasing the brakes the brakes the rubber-sealing ring acts as return spring and retract the pistons and the friction pads away from the Dual.

2.1. *Problems in dual brake*

In the journal of brake operation, frictional heat is dissipated mostly into pads and a Dual, and an occasional uneven temperature distribution on the components could induce severe thermo elastic distortion of the Dual. The thermal distortion of a normally flat surface into a highly deformed state, called thermo elastic transition.

At other times, however, the stable evolution behavior of the sliding system crosses a threshold whereupon a sudden change of contact conditions occurs as the result of instability.

This invokes a feedback loop that comprises the localized elevation of frictional heating, the resultant localized bulging, a localized pressure increases as the result of bulging, and further elevation of frictional heating as the result of the pressure increase. When this process leads to an accelerated change of contact pressure distribution, the unexpected hot roughness of thermal distortion may grow unstably under some conditions, resulting in local hot spots and leaving thermal cracks on the Dual. This is known as thermo elastic instability (TEI).

The thermo elastic instability phenomenon occurs more easily as the rotating speed of the Dual increases. This region where the contact load is concentrated reaches very high temperatures, which cause deterioration in braking performance. Moreover, in the course of their presence on the Dual, the passage of thermally distorted hot spots moving under the brake pads causes low–frequency brake vibration.

2.2. *Objective of the present work*

1. The given Dual brake rotor of its stability and rigidity (for this Thermal analysis and coupled structural analysis is carried out on a given Dual brake rotor.

2. Best combination of parameters of Dual brake rotor like Flange width, Wall thickness and material there by a best combination is suggested.

3. Problem identification

Major problem in braking system is heat generation. The following figures shows the different defects of a typical brake surface subjected to high thermal stresses.

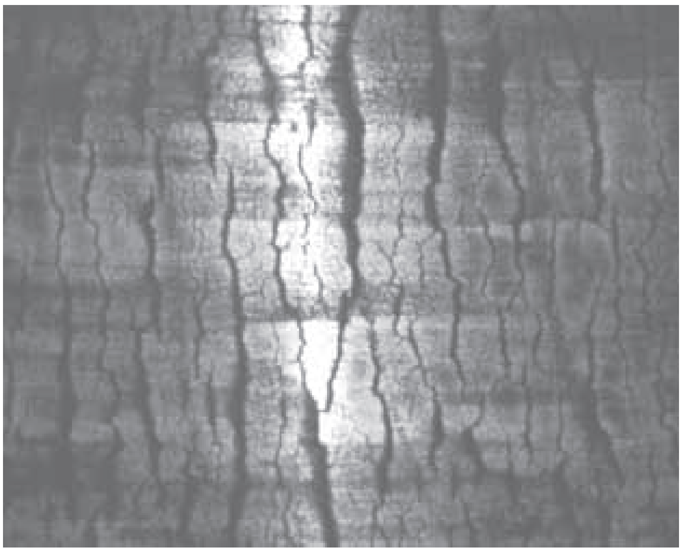

Figure 1 Brake rotor surface showing a high level of heat checking

Figure 2 Hard spot on a brake Drum

4. Structural analysis

Structural analysis is the most common application of the finite element analysis. The term structural implies civil engineering structure such as bridge and building, but also naval, aeronautical and mechanical structure such as ship hulls, aircraft bodies and machine housing as well as mechanical components such as piston, machine parts and tools.

5. Types of structural analysis

The seven types of structural analyses in ANSYS. One can perform the following types of structural analysis. Each of these analysis types are Dual used as follows:

1. Static analysis.
2. Modal analysis.
3. Harmonic analysis.
4. Transient dynamic analysis.
5. Spectrum analysis.
6. Buckling analysis.
7. Explicit dynamic analysis.

6. Generative design

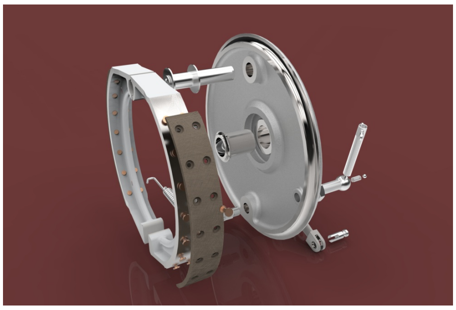

Figure 3 Front brake exploded view-1

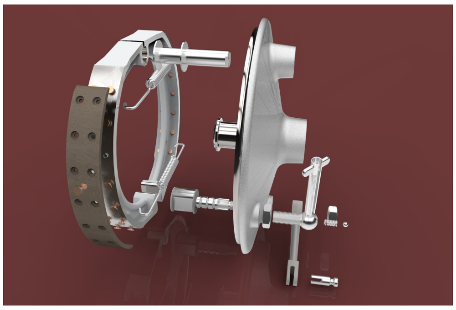

Figure 4 Front brake exploded view-2

Figure 5 Front brake assembled view-1

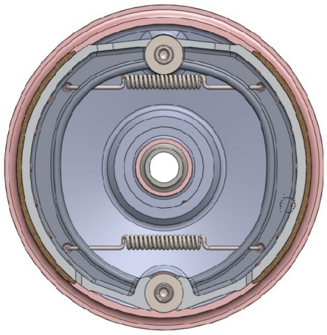

Figure 6 Front brake assembled front view

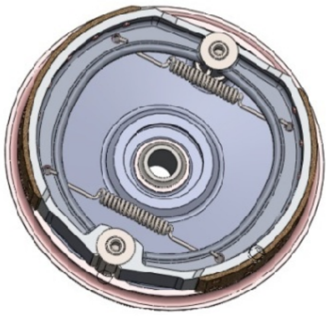

Figure 7 Front brake assembled isometric view

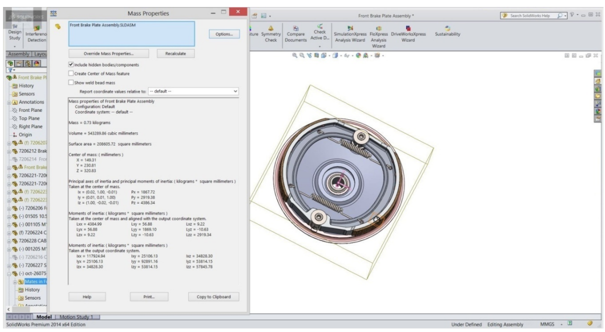

Figure 8 Front brake assembled view with solid works window

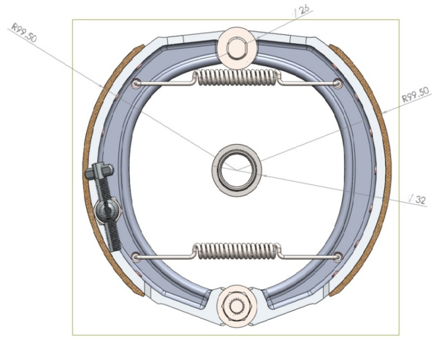

Figure 9 Front brake assembled front view with dimensions

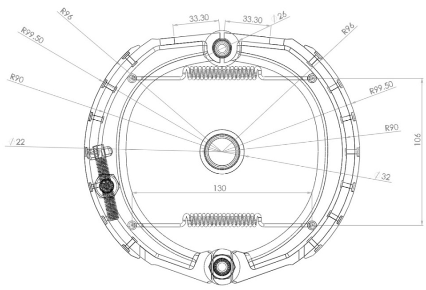

Figure 10 Front brake assembled front view with wire frame model

7. Procedure for analysis

7.1. *Define engineering data*

Material properties can be linear or nonlinear, isotropic or orthotropic, and constant or temperature–dependent. You must define stiffness in some form (for example, Young's modulus, hyper elastic coefficients, and so on). For inertial loads (such as Standard Earth Gravity), you must define the data required for mass calculations, such as density.

S.No	**Material**	**Density**	**Young's Modulus**	**Poisson's Ratio**
1	Nickel Chrome Steel	7800 kg/m^3	2e^{011} N/m^2	0.28
2	Aluminium Alloy	2600 kg/m^3	7e^{011}N/m^2	0.33

7.2. *Attach geometry*

The model includes nonlinearities such as large deflection or hyper elasticity, the solution time can be significant due to the iterative solution procedure. Hence you may want to simplify your model if possible. For example you may be able to represent your 3–D structure as a 2-D plane stress, plane strain, or axi-symmetric model or you may be able to reduce your model size through the use of symmetry or anti-symmetry surfaces. Similarly if you can omit nonlinear behavior in one or more parts of your assembly without affecting results in critical regions it will be advantageous to do so.

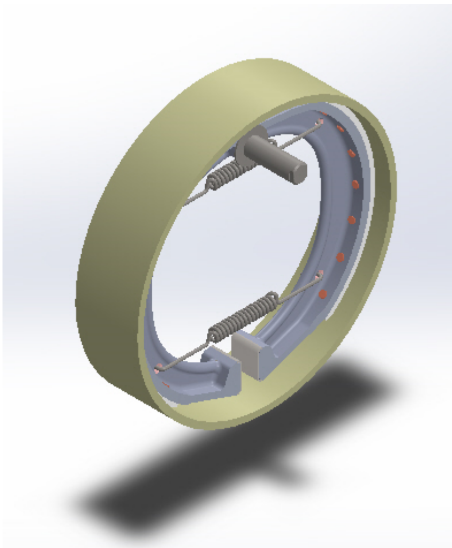

Figure 11 Attach Geometry

7.3. *Importing model in to ANSYS*

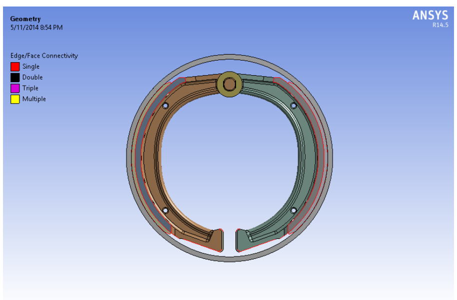

Figure 12 Importing Model into Ansys

The static structural analysis of the brake disc at fixed moment with the rotational velocity of 6207 rpm.

In this prompt, the dimensions of the real part model has been modeled using Solid Works, the solid works is best suitable only for modeling the Crane hook and the part model is imported as *.prt file. In solid works the 3 Dimensional parts has been converted into*. Para-solid file. Now we can be able to set the actual dimensions appearance for the converted model file. After setting the require data in solid works. After completing the designing processes of Crane hook. The file is imported to the Ansys software. Ansys specialized in the area of analyzing the materials and different kinds of parts .This part model may be imported to Ansys as *.IGES file. Thus the IGES file has been imported in Ansys work bench, and in Ansys, static structural analysis has been made on the IGES file. After the process it has been stored. That it can be viewed in Ansys bench as a link to Ansys products launcher. Thus the result can be generated in the general post processor using the Ansys product launcher.

The ANSYS commitment is to provide unequalled technical depth in any simulation domain. Whether it's structural analysis, fluids, thermal, electromagnetics, meshing, or process & data management we have the level of functionality appropriate for your requirements. Through both significant R&D investment and key acquisitions, the richness of our technical offering has flourished. A strong foundation for multiphysics sets ANSYS apart from other engineering simulation companies. Our technical depth and breadth, in conjunction with the scalability of our product portfolio, allows us to truly couple multiple physics in a single simulation.

Technical depth in all fields is essential to understand the complex interactions of different physics. The portfolio breadth eliminates the need for clunky interfaces between disparate applications. The ANSYS capability in multiphysics is unique in the industry; flexible, robust and architected in ANSYS Workbench to enable to solve the most complex coupled physics analyses in a unified environment.

7.4. *Apply mesh controls/preview mesh*

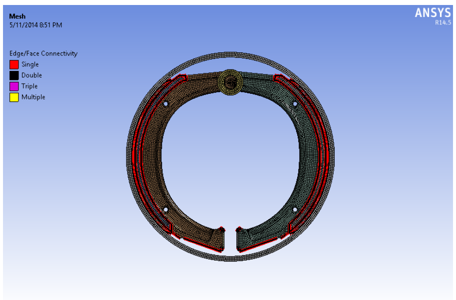

Figure 13 Applying mesh controls

7.5. *Applying Loads and Supports*

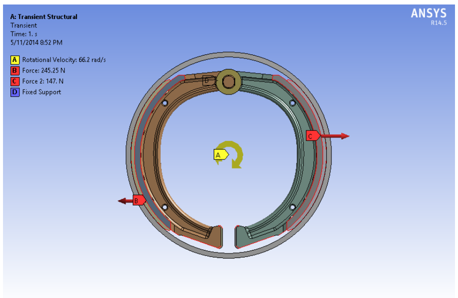

Figure 14 Applying loads and supports

8. Structural analysis of varies component

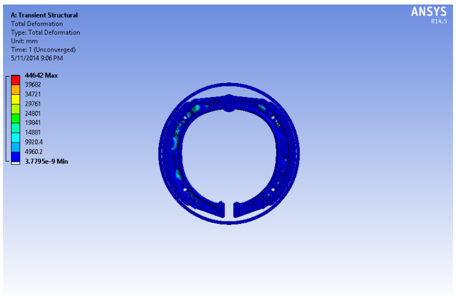

Figure 15 60 kmph speed

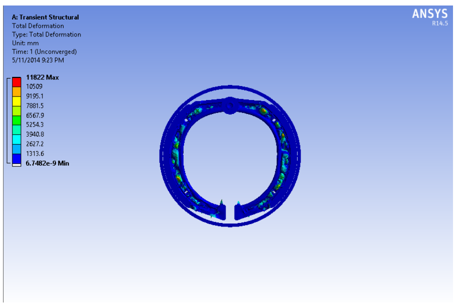

Figure 16 80 kmph speed

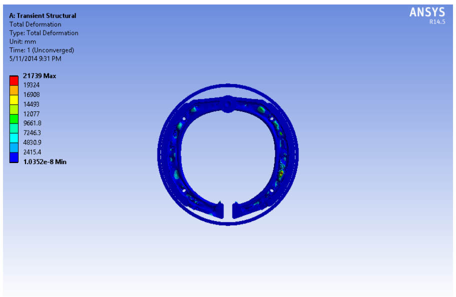

Figure 17 100 kmph speed

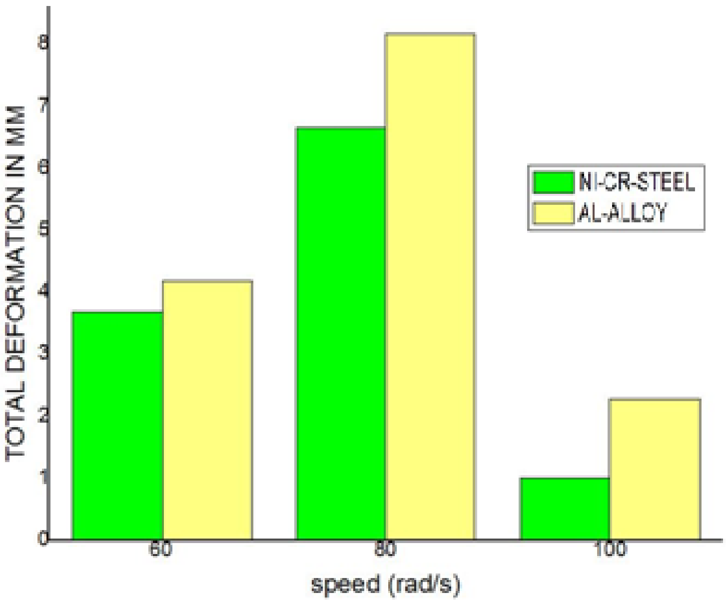

Figure 18 Total deformations at different speeds

8.1. *Velocity distribution*

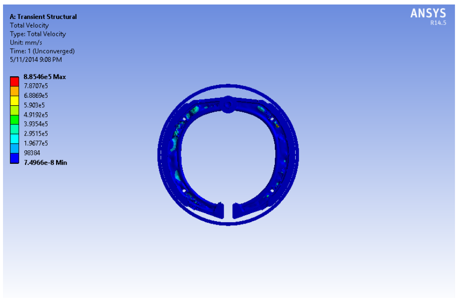

Figure 19 60 kmph speed

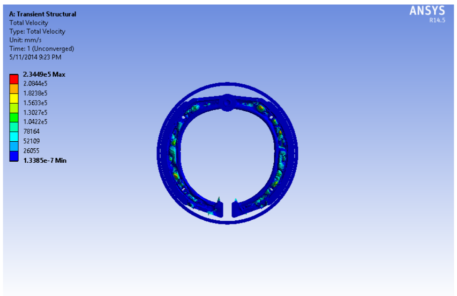

Figure 20 80 kmph speed

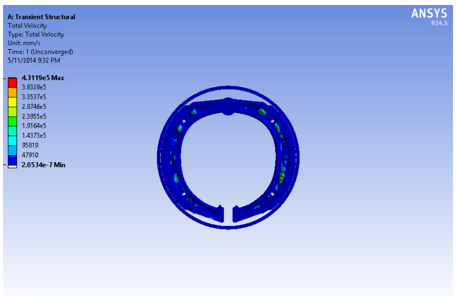

Figure 21 100 kmph speed

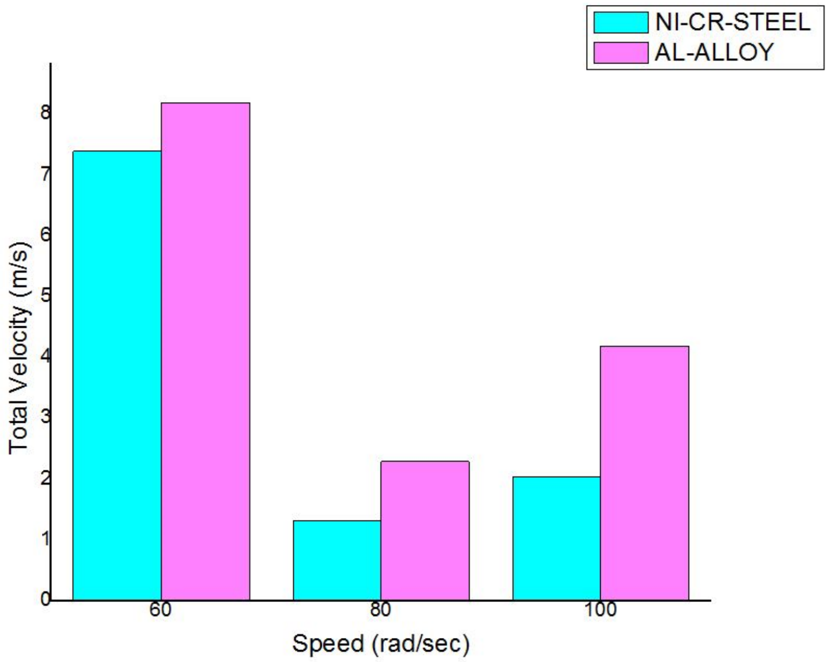

Figure 22 Velocity distributions at different speeds

9. Conclusion

In this modified braking system we increase the frictional area of braking by providing an additional brake shoe. This is different from the conventional braking system of heavy–duty vehicle.The following results were obtained from the structural analysis,

Material	Speed [rad/sec]	Velocity [m/s]	Deformation [mm]
NI-CR-STEEL	60	7.2	3.8
	80	1.2	6.8
	100	1.8	0.9
AL-ALLOY	60	8	4.1
	80	2.2	8.1
	100	4	2.3

From the structural analysis results we have concluded that the break pad with nickel chromium steel material has the minimum velocity and Deformation compared with aluminum alloy.

References

[1] **Kennedy, F. E., Colin, F., Floquet, A. and Glovsky, R.**: Improved Techniques for Finite Element Analysis of Sliding Surface Temperatures, *Westbury House*, 138–150, **1984**.

[2] **Lin, J. Y. and Chen, H. T.**: Radial Axis symmetric Transient Heat Conduction in Composite Hollow Cylinders with Variable Thermal Conductivity, 10, 2–33, **1992**.

[3] **Brilla, J.**: Laplace Transform and New Mathematical Theory of Visco elasticity, 32, 187–195, **1997**.

[4] **Tsinopoulos, S. V, Agnantiaris, J. P. and Polyzos, D.**: An Advanced Boundary Element/Fast Fourier Transform Axis symmetric Formulation for Acoustic Radiation and Wave Scattering Problems, *J.ACOUST. SOC. AMER.*, 105, 1517–1526, **1999**.

[5] **Wang, H. C. and Banerjee, P. K.**: Generalized Axis symmetric Elastodynamic Analysis by Boundary Element Method, 30, 115–131, **1990**.

[6] **Floquet, A. and Dubourg, M. C.**: Non axis symmetric effects for three dimensional Analyses of a Brake, *ASME J. Tribology*, 116, 401–407, **1994**.

[7] **Burton, R. A.**: Thermal Deformation in Frictionally Heated Contact, *Wear*, 59, 1–20, **1980**.

[8] **Anderson, A. E. and Knapp, R. A.**: Hot Spotting in Automotive Friction System, *Wear*, 135, 319–337, **1990**.