Design and Material Optimization of air Disk brake of Volvo Trucks

Mr.N.Suryanarayana
M. Tech-MACHINE DESIGN pursuing Student,
SISTAM College of Engineering, Srikakulam,

Mr. S. Chandrasekhar Reddy
Associate Professor & HOD,
SISTAM College of Engineering, Srikakulam,

Abstract

Today's technology is in need for speed, but at the same time, we need safety as well. For safety, we need deceleration to the maximum extent. These two things are moreover contradictory factors. For speed, we need engines of maximum efficiency and for keeping this speed in bounds, we need brakes of latest technology. For coping up with today, speed, new materials are introduced in the manufacture of brakes. A brake disc (or rotor in American English) is usually made of cast iron, but may in some cases be made of composites such as reinforced carbon–carbon or ceramic matrix composites. This is connected to the wheel and/or the axle.

The aim of the project is to design an disc brake for a four wheeler engine using theoretical calculations. 2D drawings are drafted from the calculations and 3D model is done in Pro/Engineer.

Structural, Model and Fatique is to be done on the disc brake. Analysis is done in ANSYS. The material used for disc brake rotor is structural steel. We are doing material optimization by doing analysis on material High carbon steel, Grey cast Iron and Manganese. Modal analysis is also done on the disc brake rotor to determine mode shapes of the rotor for number of modes.

Pro/ENGINEER is the standard in 3D product design, featuring industry-leading productivity tools that promote best practices in design.

ANSYS is general-purpose finite element analysis (FEA) software package. Finite Element Analysis is a numerical method of deconstructing a complex system into very small pieces (of user-designated size) called elements.

1.Introduction

Disc Brake is a device for slowing or stopping the rotation of a wheel. A brake disc, usually made of cast iron or ceramic, is connected to the wheel or the axle. To stop the wheel, friction material in the form of brake pads (mounted in a device called a brake caliper) is forced mechanically, hydraulically, pneumatically or electromagnetically against both sides of the disc. Friction causes the disc and attached wheel to slow or stop.

One of the most important control system of an automobile is BRAKE SYSTEM .They are required to stop the vehicle within the smallest possible distance and is done by converting kinetic energy of the vehicle into heat energy which is dissipated into atmosphere.

The main requirements of brakes are given below.

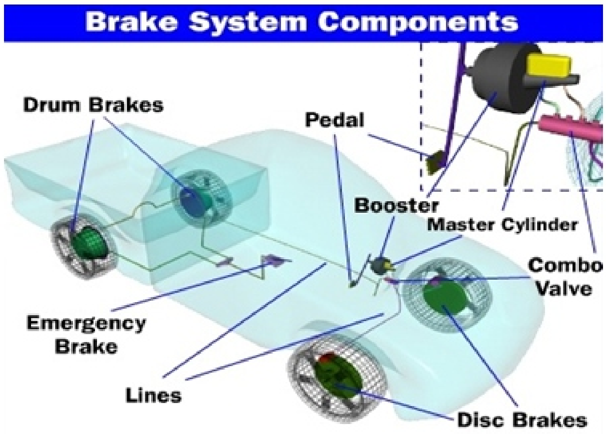

Figure. 1. Brake system.

The brakes must be strong enough to stop the vehicle within the minimum possible distance in an emergency. But this should also be consistent with safety. The driver must have a proper control over the vehicle during emergency braking and the vehicle must not skid.

The brakes must have good anti fade characteristics and their effectiveness should not decrease with constant prolonged application.

The actual stopping distance of vehicle while braking depends on the following factors:-

1.Vehicle speed

2.Condition of the road surface

3.Condition of tyre tread

4.Coefficient of friction between the tyre tread and the road surface

5.Coefficient of friction between the brake drum/disc and brake lining/friction pad .

Volume No: 1(2014), Issue No: 9 (September) ISSN No: 2348-4845

1.2 Types of brakes

The brakes for automotive use may be classified according to the following consideration

A.Purpose

» Service or primary brakes
» Parking or secondary brakes

B.Construction

» Drum brakes
» Disc brakes

C.Method Of Actuation

» Mechanical Brakes
» Hydraulic Brakes
» Electric Brakes
» Vacuum Brakes
» Air Brakes

D.Extra Braking Effort

» Servo Brakes or Power assisted brakes
» Power Operated Brake

2. Introduction to PRO/ENGINEER

Pro/ENGINEER Wildfire is the standard in 3D product design, featuring industry-leading productivity tools that promote best practices in design while ensuring compliance with your industry and company standards. Integrated Pro/ENGINEER CAD/CAM/CAE solutions allow you to design faster than ever, while maximizing innovation and quality to ultimately create exceptional products.

Customer requirements may change and time pressures may continue to mount, but your product design needs remain the same - regardless of your project's scope, you need the powerful, easy-to-use, affordable solution that Pro/ENGINEER provides.

3. Model in PRO/ENGINEER

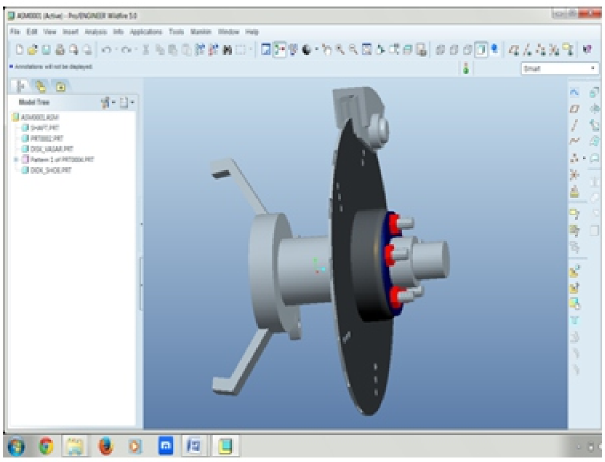

Figure.2. Air Disk Brake in PRO/E.

4.Introductin to ANSYS

Ansys is a general purpose finite element modeling package for numerically solving a wide variety of mechanical, electrical problems.

4.1 Types of ANSYS Process

1.Static/Dynamic structural analysis (both linear and non linear)
2.Fluid analysis
• Laminar flow
• Turbulent flow
3.Acoustic analysis
4.Electromagnetic analysis
5.Model analysis
6.Thermal analysis
• conduction
• convection
• radiation
7. Transient thermal analysis
8.Buckling analysis
9.Spectrum analysis
10. Harmonic analysis

5. Analysis in ANSYS
5.1 Structural Analysis Steel Material
5. A. Imported model

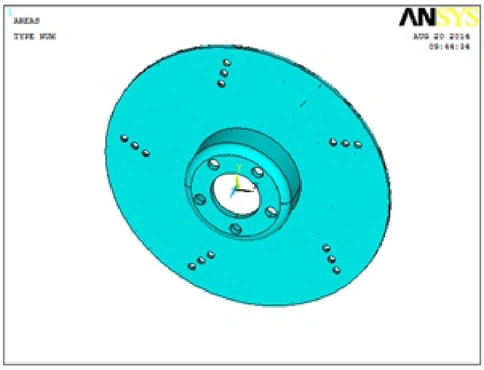

Figure. 3. Imported model from PRO/E.

5. B.Meshed model

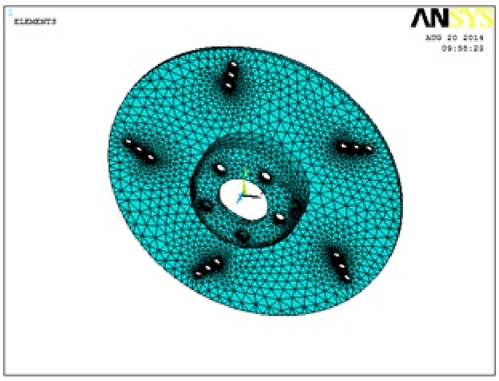

Figure. 4. Meshed model in ANSYS.
Pressure: 3.13153 N/mm2
Torque: 3.3784 N

5. C.Stress = 8.39001 N/mm2 (MPa)

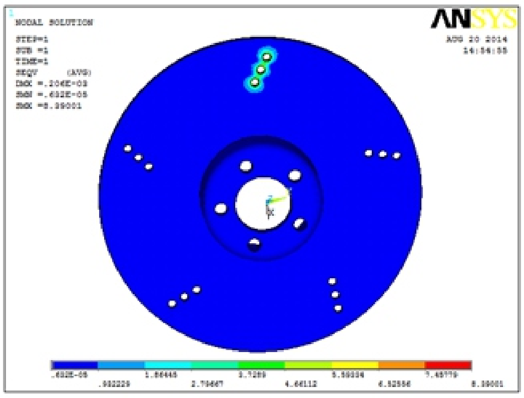

Figure. 5. Stress result in ANSYS.

5. D.Displacement = = 0.206E-03 mm

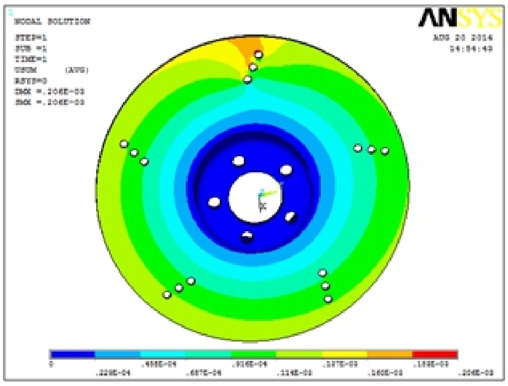

Figure. 5. Displacement result in ANSYS.

5. E. Strain = 0.519E-04

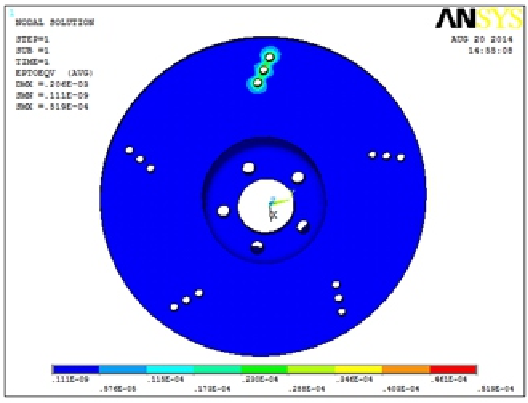

Figure. 6. Strain result in ANSYS.

6. Material Properties
6. A. High Carbon Steel

Young's Modulus(MPa)	235000
Poisson's ratio	0.313
Density (g/cc)	8.26

Table.1.Material properties of Steel.

6. B. Grey Cast Iron

Young's Modulus(MPa)	162000
Poisson's ratio	0.330
Density (g/cc)	7.34

Table.2.Material properties of Grey cast Iron.

6. C. Manganese

Young's Modulus(MPa)	159000
Poisson's ratio	0.35
Density (g/cc)	7.44

TableTable.3.Material properties of Manganese.

7.Model Analysis
7.1 A. Mode – 1 = 3.83993

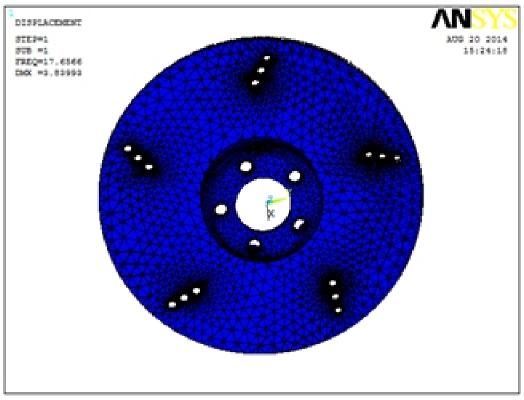

Figure. 7. Mode 1 Displacement Result.

7.2 B. Mode – 2 = 3.82357

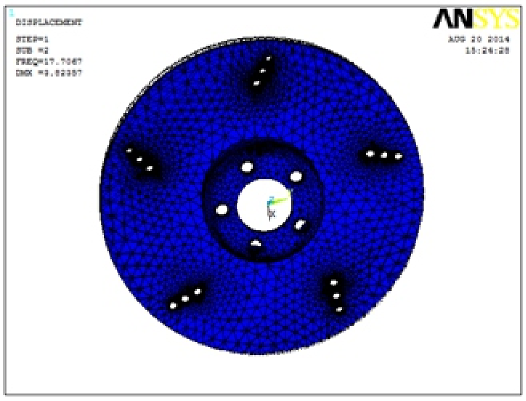

Figure. 8. Mode 2 Displacement Result.

7.3 C. Mode – 3 = 3.7801

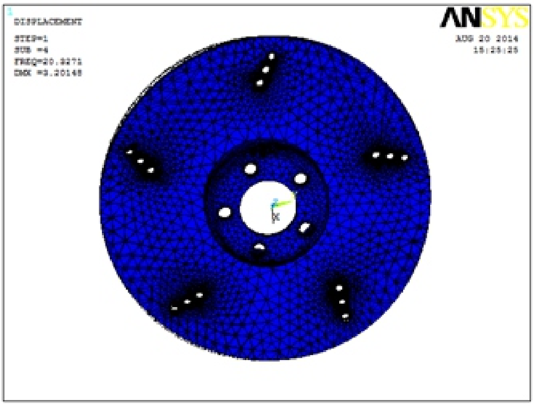

Figure. 9. Mode 3 Displacement Result.

7.4 D. Mode – 4 = 3.20408

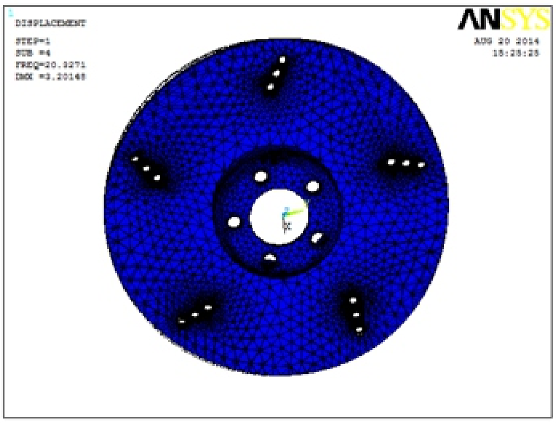

Figure. 10. Mode 4 Displacement Result.

7.5 E.Mode – 5 = 3.24897

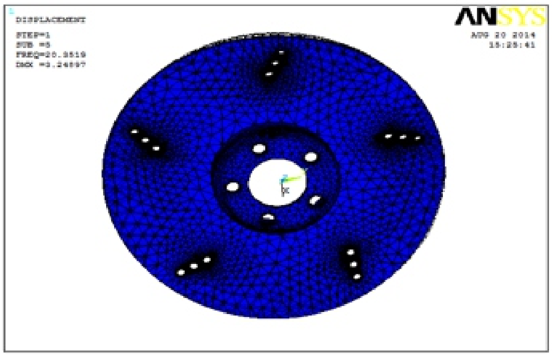

Figure. 11. Mode 5 Displacement Result.

8.Fatique Analysis Grey Cast Iron

8.A. At Node – 2066

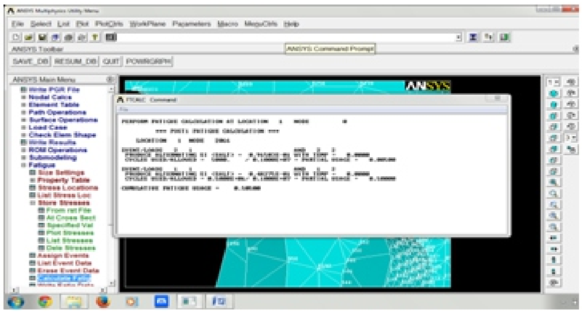

Figure. 12. Fatique Result in ANSYS

8.B. At Node – 5240

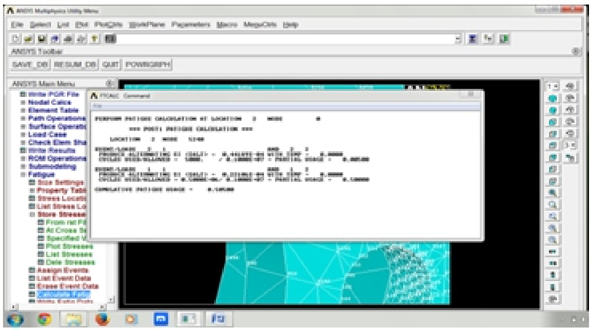

Figure. 13. Fatique Result in ANSYS.

8.C. At Node – 492

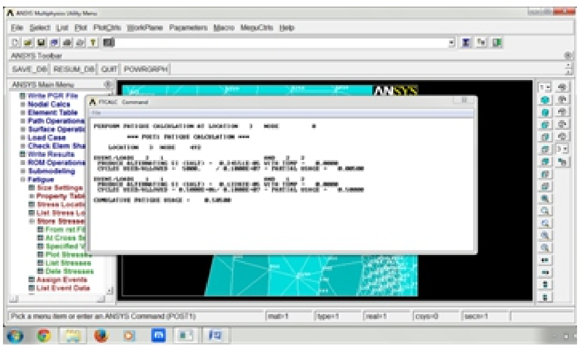

Figure. 14. Fatique Result in ANSYS.

Location: 1 Node 2066 at the fixed end.

The combination of event 2, load 1 and event 2, load 2 produces an alternating stress intensity of 0.9650.E-01 N/cm2. The spring was subjected to 5000 cycles while from the S-N Table; the maximum number of cycles allowed at that stress intensity is 0.1110 E07. The partial usage value, 0.00500, is the ratio of cycles used/cycles allowed.

The combination of event 1, load 1 and event 1, load 2 produces an alternating stress intensity of 0.48275E-01 N/cm2. The spring was subjected to 500,000 cycles while from the S-N Table; the maximum number of cycles allowed at that stress intensity is 0.1110 E07. The partial usage value, 0.00500, is the ratio of cycles used/cycles allowed.

The Cumulative Fatigue Usage value is sum of the partial usage factors (Miner's rule).

9.Results
9.A. Structural Analysis

Materials	Displacement(mm)	Stress(N/mm^2)	Strain
High Carbon Steel	0.125e-^{03}	8.44235	0.360e-^{04}
Grey Cast Iron	0.206e-^{03}	8.39001	0.519e-^{04}
Manganese	0.441e-^{03}	8.51799	0.536e-^{04}

Table.4.Results of Structural Analysis.

9.B. Model Analysis

Materials	Mode 1	Mode 2	Mode 3	Mode 4	Mode 5
High Carbon Steel	3.83993	3.82357	3.7801	3.20148	3.24897
Grey Cast Iron	3.4246	3.5522	3.44239	3.01468	3.05852
Manganese	7.22115	6.41608	6.09307	6.27294	6.28994

Table.5.Results of Structural Analysis.

10.Conclusion

The disc brake is designed from the fundamentals. Pro/Engineer software is used in modeling the disc brake.

ANSYS is being used for Structural, Model and Fatigue of the disc rotor using High carbon Steel, Grey cast iron and Manganese. The following results are obtained during the analysis. The material used for the Disk Brake Rotor is High carbon steel. We have replaced that material using Grey cast iron and Manganese.

As per the material properties and conclusions, the design is safe and the Grey cast iron is best suitable than high Carbon steel for disc brake rotor.

The Stress Values of the Grey Cast iron is less than the High carbon steel and Manganese.

Model analysis the Displacement of the Grey Cast iron is low comparatively remaining two Materials.

Fatigue analysis is also done on the disk rotor using 500000 cycles the Grey cast iron will be have high stress intensity.

So we have to conclude that the Grey cast iron is good for Manufacturing of Disk rotor.

11.References

1. Andrew, I. & Beaumont, R. (2007, Oct. 2). Retrieved Sept. 23, 2008, from http://www.cdxetextbook.com/index.html

2. ANSYS User Manual

3. Chandrupatla, T. R. & Belegundu, A. D. (2008). Introduction to Finite Elements in Engineering. (Vol. 3, A. K. Ghosh, Ed.). Connaught Circus, ND: Prentice-Hall of India Private Limited.

4. Lawrence, K. L. (2006). ANSYS Tutorial. (Vol. Release 10,). Mission, KS: SDC

5. Metcalfe, L. (n.d.). In Nation Master. (chap. List of Materials Properties). Retrieved Oct. 25 , 2008, from http://www.nationmaster.com/encyclopedia/List-of-materials-properties

6. Nice, K. (n.d.). How Disc Brake Works. (sect. Disc Brake Basic). Retrieved Sept. 22, 2008, from http://auto.howstuffworks.com/disc-brake1.htm

7. Rao, S. S. (2005). The Finite Element method in Engineering. In Overview of Finite Element Method (ed. 4, p. 3-43). Srinivaspuri, ND: Elsevier

8.White, M. A. (1999). Properties of Materials. Thermal Properties of Materials (p. 91-155). New York, NY: Oxford University Press, Inc engineering inspections.