Research Article Impact Factor: 4.226 ISSN: 2319-507X
Yugesh Anil Kharche, IJPRET, 2015; Volume 3 (7): 56-62 IJPRET

INTERNATIONAL JOURNAL OF PURE AND APPLIED RESEARCH IN ENGINEERING AND TECHNOLOGY

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DESIGN AND FEM BASED ANALYSIS OF DISC BRAKE FOR FOUR WHEELER

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Accepted Date: 26/02/2015; Published Date: 01/03/2015

Abstract: The disc brake is a device for decelerating or stopping the rotation of a wheel. Braking is a process which converts the kinetic energy of the vehicle into mechanical energy which must be dissipated in the form of heat. This paper presents the analysis of the contact pressure distributions at the disc interfaces using a detailed 3-dimensional finite element model of a real car disc brake. Finite element (FE) models of the brake-disc are created using Pro-E and simulated using ANSYS which is based on the finite element method (FEM). It is also investigates different levels in modeling a disc brake system and simulating contact pressure distributions at varying load. It covers Finite Element Method approaches in the automotive industry the Contact analysis and thermal analysis. The effect of the angular velocity and the contact pressure distribution on temperature rise of disc brake was investigated. Wear in friction material means that reduction of its life span. The more the wear, the sooner the frictional material needs to be replaced. Different Brake pad material is tested as compared with the existing one. Finally comparison between analytical results and result obtained from Ansys carried out, and all the values obtained from the analysis are less than their allowable values. Hence on the basis of thermal and contact stress analysis best suitable material is suggested.

Keywords: Disc Brake, FEM Based, Four Wheeler

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How to Cite This Article:

Yugesh Anil Kharche, IJPRET, 2015; Volume 3 (7): 56-62

PAPER-QR CODE

INTRODUCTION

The disc brake is a device for slowing or stopping the rotation of a wheel. A brake disc usually made of cast iron is connected to the wheel or the axle. To stop the wheel, friction material in the form of brake pads mounted on a device called a brake calliper) is forced mechanically, hydraulically, pneumatically or electromagnetically against both sides of the disc. Friction causes the disc and attached wheel to slow or stop. Brakes (both disc and drum) convert friction to heat, but if the brakes get too hot, they will cease to work because they cannot dissipate enough heat

Today, most passenger vehicles are fitted with disc brake systems. A disc brake system typically consists of two pads, a calliper, a disc, a piston, a carrier bracket and two guide pins. One of the major requirements of the calliper is to press pads against the disc and it should ideally achieve as uniform interface pressure as possible. Repetitive braking action rise in temperature due to friction and brake pad life shorten. This might lead to dissatisfaction to the customers who need to visit their garage more frequently in order to replace wear brake pads.

The friction heat generated between two sliding bodies causes deformation which alters the contact pressure distribution. The sliding contact of the members of disc brake results in kinetic energy conversion into heat at the pad/disc interface. The increase of friction moment is a limited quantity and depends on the coefficient of friction, radius of rubbing path, and forces that act on the pads. The braking system is very crucial in stopping the car on all moving stages including during high speed, sharp cornering and downhill movements. The ability to bring a vehicle safe controlled stop is absolutely essential in preventing accidental vehicle damage and personal injury. The aim of the project is to show how to perform a crashworthiness simulation in the automobile industry using Finite Element Method. The effect of the angular velocity and the contact pressure distribution on temperature rise of disc brake pad was investigated. Finite element model is prepared and analysis is done with the help ansys software. Different material is to be tested so as to compare the existing brake lining material with the other brake lining material and suggest the new brake linear material for the present application.

The customer needs to be visited in garage more frequently for the replacement of the brake pad because the existing brake pad wear. Once the brake pad wears up to certain limit it reduces its efficiency. The customer has to apply more brake power for same braking application. Once the braking efficiency reduces, it is not safe for the both passenger vehicle and the other vehicle on the road. And also the replacement for the new break pad is more time consuming. This added the more labour cost for the customer.

My work is to suggest the new brake pad material which is having more life than the existing brake pad material by keeping the existing dimensions same.

2.0 MAIN COMPONENTS OF DISC BRAKING SYSTEM

2.1 Discs/rotor

The rotor, also known as the brake disc, is attached to the wheel and axel. It is made of cast iron materials that are highly machined. Since the linings clamp against the rotor to stop it, both sides are machined to provide a smooth braking surface. The rotor must also be the same thickness throughout its diameter. Variations in thickness will cause pulsation when the brakes are applied. Rotors can be either ventilated or solid. Solid rotors have no openings between the machined surfaces and Ventilated rotors have internal fins between the two friction surfaces. Ventilation slots in the rotor allow air to move through the system and cool the rotor during use. The actual disc are also drilled and slotted on the surface to increase surface area for cooling on high performance brakes. Friction from the brake pads slows the rotor, which in turn, slows the wheel. Rotors vary in thickness and size due to the type of car and application they will be put on. Disc brake discs are commonly manufactured out of a material called grey iron.

2.2 Calipers

The brake caliper is the assembly which houses the brake pads and pistons. The pistons are usually made of aluminum or chrome-plated steel. There are two types of calipers: floating or fixed. A fixed caliper does not move relative to the disc. It uses one or more pairs of opposing pistons to clamp from each side of the disc, and is more complex and expensive than a floating caliper. A floating caliper moves with respect to the disc, along a line parallel to the axis of rotation of the disc; a piston on one side of the disc pushes the inner brake pad until it makes contact with the braking surface, then pulls the caliper body with the outer brake pad so pressure is applied to both sides of the disc.

2.3 Brake Pad

Different brake design application requires different kinds of frictions materials. Several consideration are weighed in development of brake pads, the coefficient of friction must remains constant over a wide range of temperature, the brake pad must not wear out rapidly nor should they wear the disc rotor, should withstand high temperature without fading and it should be able to do all these without any noise.

2.4 Master cylinders

The pistons in the master cylinder push brake fluid to the individual brakes, causing the pistons in the brake cylinders to apply the brakes. As the brakes wear, fluid is added to the system from the brake fluid reservoir in the master cylinder. The reservoir's gasket and cover are designed to keep contaminants out of the fluid. A brake master cylinder contains a primary piston and a secondary piston. When the brake pedal is pressed, the master cylinder push rod pushes the primary piston. The primary piston closes the return port and applies pressure to the hydraulic fluid between the primary and secondary pistons. The secondary piston is pushed forward and hydraulic pressure is transferred to the brakes controlled by that piston. Once pressure on the brake pedal is released, hydraulic pressure and a spring return the primary piston. The piston returns more quickly than the brake fluid can return from the brakes, so brake fluid from the reservoir fills the space between the two pistons. Once the primary piston has returned, all excess brake fluid returns to the reservoir. This process is similar for the secondary piston.

2.5 Brake fluid

Brake fluid maintains its performance even when extremely hot or cold. The United States of America federal government's Department of Transportation (DOT) sets minimum standards for brake fluid. Brake fluid must be noncorrosive to all brake system parts and have a very high boiling point. Chemical and physical characteristics must not change as a result of long storage, cooling, or heating. Brake fluid must have a low freezing point and must have lubrication properties.

2.6 Brake line system

Brake lines are a series of steel tubes that contain brake fluid. Pressure created in the hydraulic system by the master cylinder is transmitted through the fluid in the brake lines to other brake system components. Brake lines must be strong enough to withstand the great pressures exerted by the brake fluid. Steel brake lines are used on the vehicle except in areas where the line must move or flex. Special rubber flexible lines are used in areas that require the brake line to move or flex. The under body to the brakes at the wheels is one example of when a flexible line is needed.

3.0 OBJECTIVE OF WORK

Following are the project objectives:-

- To study & simulate Disc brake assembly.

- To prepare FEM MODEL for Contact Analysis.
- To compare static contact pressure distributions for varying conditions.
- To suggest the new brake linear frictional material.

3.1 PROBLEM DEFINITION

- The aim of the project is to show how to perform a crash worthiness simulation in the automobile industry using Finite Element Method.
- Repetitive braking of the vehicle leads to heat generation during each braking event causes rise in temperatures which will affect the performance of the braking system.
- Problems such as premature wear of brake pads and thermal cracking of brake discs are attributed to high temperatures.
- As the brake liner frictional material wears it needs to be replaced every time due to heat generation and friction.
- Wear can take place when two or more bodies in frictional contact slide against each other. Wear in friction material means that reduction of its life span.

4.0 PART DESCRIPTION

During the braking process the brake pad and brake disc are come in frictional contact. The exact design and dimensions are taken from the Jaika Motors Limited, MIDC Hingana. The figure shows the image of the brake disc and pad. The existing material properties of cast iron and brake pad as shown in table below.

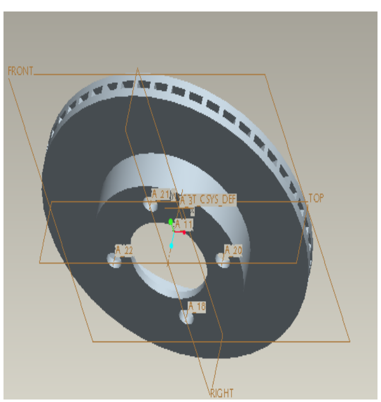

Figure 4.1: Modeling of brake Disc

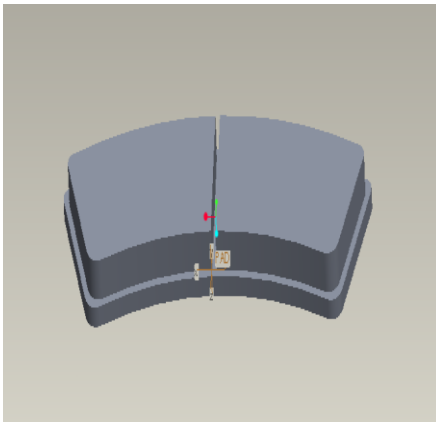

Figure 4.2: Modeling of brake pad

Table 4.1: material properties of rotor and existing pad

Properties	Cast Iron (DISC)	Existing pad
Density	7.4 g/cm^3	2.58 g/cm^3
Young's modulus (E)	130 Gpa	72.9Gpa
Poisson's ratio	0.27	0.22
Thermal conductivity	55 W/mK	1.3 W/mK
Specific Heat	447 J/KgK	810 J/KgK
Coefficient of thermal expansion	10e-6 /K	5.4e-6 /K

CONCLUSION

In this study, that the Pressure analysis and the thermal analysis for different brake pad material is examine. Different brake pad material is tested as compared with the existing brake pad material. It was observed that ceramic material is safe as compared to the other materials. Also, the result was validated by comparison with the analytical values and the software values. Hence, the ceramic material is best for the present application.

Through this analysis, the followings are summarized and pointed out

- On the basis of total deformation, equivalent stress, strain energy lost, total energy loss and thermal error the ceramic material is safe.
- On the basis of shear stress kelvar-29 is more safe.
- On the basis of temperature distribution and total heat flux the s2- glass fibre is safe.
- But, the overall pressure analysis and thermal analysis the ceramic material is much better than the other materials.

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