Thermomechanical Analysis of Disc Brake Pads using CAE Tools

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Abstract— Brake pads are a component of disc brakes used in automotive and other applications. Brake pads are steel backing plates with friction material bound to the surface that faces the disk brake rotor. A brake pad is a grouping of certain materials on a metal backing that attaches to the calipers in a disk braking system. This pad can be made from several different types of material. It serves to absorb energy and heat during the braking process, facilitating the slowing of a vehicle. The brake pads do wear down with use, eventually needing replacement .In this present paper first of all find out the brake pads which is used in automobile industries and laboratory testing of the material is proceed and then thermo mechanical analysis is done for the finding out the stresses and maximum temperature. The analysis is done in ANSYS.

Key words: Brake Pads, laboratory testing, Analysis Software

I. INTRODUCTION

Brake pads convert the kinetic energy of the car to thermal energy by friction. Two brake pads are contained in the brake caliper with their friction surfaces facing the rotor. When the brakes are hydraulically applied, the caliper clamps or squeezes the two pads together into the spinning rotor to slow/stop the vehicle. When a brake pad is heated by contact with a rotor, it transfers small amounts of friction material to the disc, turning it dull gray. The brake pad and disc (both now with friction material), then "stick" to each other, providing the friction that stops the vehicle.

In disc brake applications, there are usually two brake pads per disc rotor, held in place and actuated by a caliper affixed to a wheel hub or suspension upright. Although almost all road-going vehicles have only two brake pads per caliper, racing calipers utilize up to six pads, with varying frictional properties in a staggered pattern for optimum performance. Depending on the properties of the material, disc wear rates may vary. The brake pads must usually be replaced regularly (depending on pad material), and most are equipped with a method of alerting the driver when this needs to take place. Some have a thin piece of soft metal that causes the brakes to squeal when the pads are too thin, while others have a soft metal tab embedded in the pad material that closes an electric circuit and lights a warning light when the brake pad gets thin. More expensive cars may use an electronic sensor.

A. Materials of Brake Pads:

Brake pad materials range from asbestos to organic or semi-metallic formulations. Each of these materials has proven to have advantages and disadvantages regarding environmental friendliness, wear, noise, and stopping capability.

- Asbestos
- Semi-Metallic
- Non-Asbestos Organics
- Low Steel
- Carbon
- Exact composition of each manufacturer's pads is a closely guarded secret

B. Semi-Metallic Materials:

The most common brake pads for vehicles today are semi-metallic. These brake pads are composed of metal shavings held together with resin. Some of the most common metals are copper, brass, and steel. Because they are crafted of primarily metal, these brake pads are very durable and can last a long time before needing replacement. They are also relatively inexpensive. However, their metallic nature also subjects them to more grinding noises, considering they are being rubbed against a metal brake rotor for the purpose of creating friction. Each manufacturer has its own formulation for brake pad materials, and it is generally a highly guarded secret formula. Many after-market brake pads are touted as being quieter than the standard versions.

- Low to medium coefficient of friction ~ 0.28 –0.38
- Relatively high mu variation (temperature, duty cycle)
- Good fade characteristics
- Poor wear at low temps., <100C
- Excellent wear at temps. over 200C
- Good wear under heavy loads
- Poor wear at high speeds
- Generally inferior Noise, Vibration & Harshness compared to NAOs
- Contains no copper
- Low initial cost
- High fluid temperatures can be an issue

Material	Advantages	Drawbacks
Semi-Metallic	Readily available; inexpensive; good performance; durable	Causes quicker wear on rotors; heaviest, impacting gas mileage; needs time to warm up
Organic	Quieter; environmentally friendly	Wear quickly; create more dust
Ceramic	Best performance; incredibly durable; lightweight	Expensive

II. METHODOLOGY

A. Laboratory Testing:

Now a day which types of material is used for brake pads is known by the help of laboratory testing of the materials . By the laboratory testing of the material the composition of the brake pads is known mean how many percent material is used for binding, abrasive, fillers, fibers. So that here the composition of the brake pads.

- Al_2O_3 – 0.41%

- FeO – 0.36%
- Fe_2O_3 – 2.07%
- C_aO – 0.76%
- K_2O – 15.18%
- SiO_2 - 39.16%
- M_gO – 41.06%

B. Calculation for the Braking Parameters:

The Braking Parameters are find out by Practically driving the car at different speed and its obtained.
The three different speed at 40km/h , 60 km/h , 80km/h driving the car . The RPM of this different speed is 1100, 1130, and 1170.

Now By the help of this data finding the torque ,braking force

Speed km/h	Rpm	Stopping time (sec)	Torque(Nm)	Braking force (N)
40	1100	2.2	757.38	6050
60	1130	2.9	737.28	6319.31
80	1170	5.0	712.07	4888.88

C. Thermo Mechanical Analysis of the Brake Pads:

Thermal analysis is a vital stage in the study of brake systems, because the temperature determines the thermomechanical behavior of the structure. In the braking phase, temperatures and thermal gradients are very high. This generates stresses and deformations whose consequences are manifested by the appearance and the accentuation of cracks . It is thus important to determine with precision the temperature field of the brake disc. During stop braking, the temperature does not have time to be stabilized in the disc. A transient analysis is required. It is also essential to evaluate the thermal gradients, which requires three-dimensional modeling of the problem. The thermal loading is represented by a heat flux entering the disc through the brake pads.Many studies of brake disc thermomechanical coupling analysis have been done. Choi and Lee developed an axisymmetric finite element model for the thermoelastic contact problem of the brake disc and investigated the thermoelastic instability phenomenon of the disc brake during the drag-braking process and repeated braking process . Gao and Lin analyzed the transient temperature field and thermal fatigue fracture of the solid brake disc by a three-dimensional thermal-mechanical coupling model.

Here is the analysis work in ansys. By the use of the Finite Elements Method is used for the analysis and for the analysis,properties of the materials is require so that here is the properties of materials.

- Material- Semimetalic
- Young's modulus- 12.19 Gpa
- Poisson's ratio- 0.26
- C.O.F- 0.35 to 0.45
- Compressive Strength- 61.20 N/mm^2
- Force- 6319.31 N
- Velocity- 60 Km/h
- Torque- 737.28 N
- RPM- 1130
- Stopping time - 2.9 sec.
- Density- 1400 Kg/m^3
- Thermal conductivity- 5 w/m˚C
- Specific Heat- 1000 J/Kg ˚C
- Thermal expansion - 1o (10^-6/˚C)
- Elastic modulus - 1Gpa.

III. RESULT AND DISCUSSION

The analysis is completed in ansys by the FEM and the result of the analysis is in the form of the stresses and the maximum temperature of the materials. So that by this results the maximum principle stress and the von misses stress , deformation ,directional deformation, heat flux, maximum temperature of the material is known.

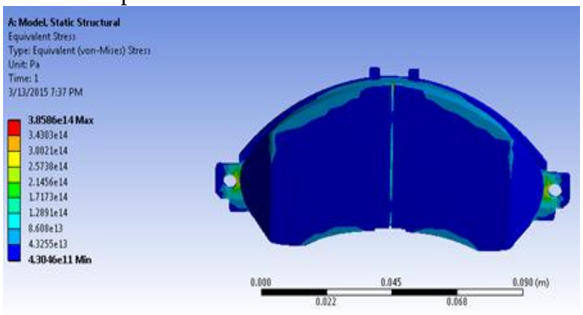

Fig. 1: Equivalent Stresses

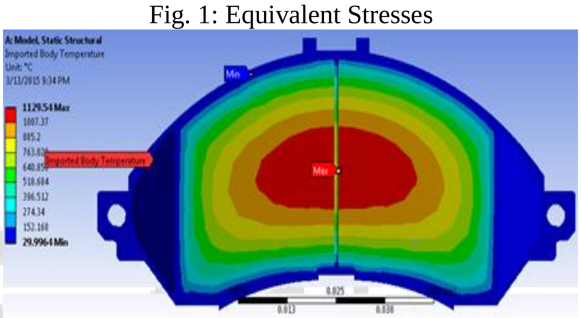

Fig. 2: Max Temp

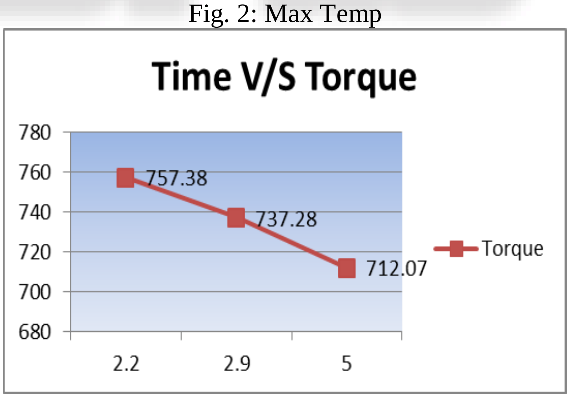

Fig. 3: Time V/S Torque

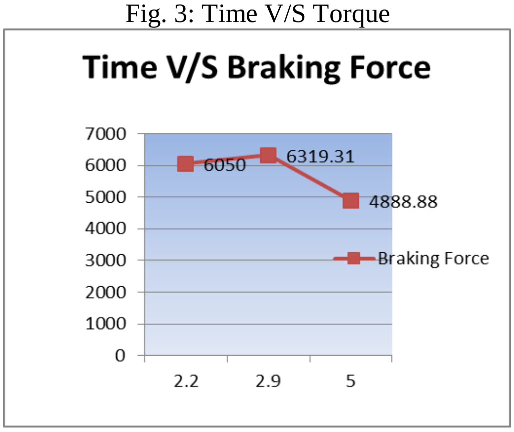

Fig. 4: Time V/S Braking Force

IV. FUTURE SCOPE

Here in this paper the first finding the composition of brake pads and by this composition of the materials the analysis is done and finding out the maximum stress and the temperature , so that for better life of the brake pads the stresses acting on the brake pads is minimized and also the operating temperature is minimized . So that the properties is minimized and the life of the brake pads is increase.

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