BRAKE DISC STATIC SIMULATION

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ABSTRACT

This paper presents a study, analysis, modeling, and simulation and comparing between different types of brake systems. The study includes stress, strain, displacement, deformation, and thermal effects on the brake disc during operations. It is found that the brake disc exposes many effects like stress, strain; deformation resulted from vibration, and thermal stresses and temperature gradients.

KEYWORDS: Brake System, Thermal Effects, Stress, Strain & Brake Disks

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INTRODUCTION

Brake system is considered as the spirit of the car, it controls the motion of the car, and the brake systems' function is to convert the kinetic energy of the moving vehicle into heat. The brake engineer has two functions:

- Create enough deceleration to stop the car as quickly as the driver wishes, without exceeding the drivers comfort level with regard to pedal effort or pedal travel.
- Manage the resulting heat energy so as not to damage the brake system or the rest of the vehicle.

Simple Brake System

The brake system simply constructed from many parts as shown in figure 1 below.

Figure 1: A Simple Brake System [1]

From figure 1 the distance from the pedal to the pivot is four times the distance from the cylinder to the pivot, so the force at the pedal will be increased by a factor of four before it is transmitted to the cylinder. It can be noticed that the diameter of the brake cylinder is three times the diameter of the pedal cylinder. This further multiplies the force by nine. All together, this system increases the force of your foot by a factor of 36. If you put 5kg of force on the pedal, 180kg will be generated at the wheel squeezing the brake pads.

There are a couple of problems with this simple system. If it is a slow leak, eventually there will not be enough fluid left to fill the brake cylinder, and the brakes will not function. If it is a major leak, then the first time you apply the brakes all of the fluid will squirt out the leak and you will have complete brake failure. The master cylinder on modern cars is designed to deal with these potential failures.

Principle of Work of Brake System

It is known that pushing down on the brake pedal slows a car to a stop. But how does this happen? How does the car transmit the force from your leg to its wheels? How does it multiply the force so that it is enough to stop something as big as a car? Figure 2 shows the brake system for some given car.

Figure 2: Brake System of the Car

When depressed brake pedal, the car transmits the force from your foot to its brakes through a fluid. Since the actual brakes require a much greater force than it could apply with the leg, the car must also multiply the force of the foot. It does this in two ways:

- Mechanical advantage (leverage); and
- Hydraulic force multiplication.

The brakes transmit the force to the tires using friction, and the tires transmit that force to the road using friction also. Before we begin our discussion on the components of the brake system, we'll cover these three principles: Leverage; Hydraulics; and Friction. Most modern cars have disc brakes on the front wheels, and some have disc brakes on all four wheels. This is the part of the brake system that does the actual work of stopping the car. The most common type of disc brake on modern cars is the single-piston floating calliper (Figure 3).

Figure 3: Brake Disc

Figure 4 demonstrates the location of the disc brakes in a car:

Figure 4: Brake Discs Location

The main components of a disc brake are:

- The brake pads;
- The caliper, which contains a piston; and
- The rotor, which is mounted to the hub.

Figure 5: Components of Disc Brake

The disc brake is a lot like the brakes on a bicycle. Bicycle brakes have a caliper, which squeezes the brake pads against the wheel. In a disc brake, the brake pads squeeze the rotor instead of the wheel, and the force is transmitted hydraulically instead of through a cable. Friction between the pads and the disc slows the disc down. A moving car has a certain amount of kinetic energy, and the brakes have to remove this energy from the car in order to stop it. How do the brakes do this? Each time you stop your car, your brakes convert the kinetic energy to heat generated by the friction between the pads and the disc. Most car disc brakes are vented. Figure 6.

Figure 6: Disc Brakes and Vents

MODELING AND SIMULATION RESULTS AND DISCUSSION

In this chapter the brake system is analyzed using Solidworks application showing the stress, strain, displacements and temperature distributions during its operation.

Figure 7 shows Solid works brake model.

Figure 7: Solid Works Brake Model

Figure 8 shows the model information and forces affect the brake disc.

Figure 8: Model Information

Figure 9 shows the disc meshing

Figure 9: Brake Disc Meshing

Figure 10 shows the stress distribution of brake disc.

Figure 10: Von-Mises Stress Distribution

Figure 11 shows the displacement distribution of the brake disc

Figure 11: Displacement Distribution of the Brake Disc

Figure 12 shows the brake disc strain distribution

Figure 12: Strain Distribution of Brake Disc

Figure 13 shows the factor of safety of the disc of the brake during brake.

Figure 13: Factor of Safety of the Brake System

Figure 14 shows the frequency analysis-vibrations of the brake disc

Figure 14: Frequency Analysis of the Brake Disc

Figure 15 mode shapes of the brake disc with frequency of 381.21 Hz, deformation.

Figure 15: Deformation of Brake Disc

Table 1 shows the brake disc deformation under a given values of frequency.

Table 1: Mode Shapes of the Brake Disc

Mode Number	Frequency (Hertz)	X Direction	Y Direction	Z Direction
1	266.45	0.078529	0.00014044	0.50746
2	381.21	0.000216	0.13541	1.0418e-005
3	650.06	3.1662e-007	1.2762e-006	2.3172e-007
4	831.74	0.031248	0.00022515	0.18095
5	1017.2	0.00037593	0.74966	3.8931e-006
		Sum X= 0.11037	Sum Y= 0.88543	Sum Z = 0.68843

CONCLUSIONS

It is clear that the brake systems play an important rule as a control systems in automobiles. It can make deceleration for the speed of the cars as needed.

Many factors affect the operation of different types of brake systems which can be summarized as

- The braking system affects at high grades by friction between the disk and brake pads.
- As the friction increase the temperature of the disk increases and so some thermal stresses appear, which affects the efficiency of the brake system.
- There are some deformations on the disc caused by vibrations during brake operation
- High values of stresses, strains, and displacements on the brake disc during its operation.

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