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Problems Associated With Existing Disc Brake Rotors and Suggestion of Alternate Ways

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Abstract

Vehicle safety in automobile engineering is considered as a first priority in production of new vehicle. Each component of a vehicle has been studied and analyzed in order to meet safety requirements, instead of having air bag good suspension system good handling and safe cornering there is one most critical system in the vehicle will put a passenger in unsafe position. Therefore it is a must for all vehicles to have proper brake system.

Vehicle braking system is the most important component regards to safety of automobile, therefore so many researchers conducted a study on brake system and its entire component. In this paper study is more concerned about the problems, structural strength, heat and temperature distribution on disc brake rotor.

The heat dissipation and thermal performance of ventilated brake discs strongly depends on the aerodynamic characteristics of the air flow through the rotor passages. So in order to improve the aerodynamic air flow in the rotor the vane geometry of the ventilated rotor has been changed and holes have been cross drilled in the rotor.

Keywords: *Disc brake, Rotor, CFD ,Drum ,Disc*

1. Introduction

The braking process is in fact the matter of energy balance. The aim of braking system is to transform mechanical energy of moving vehicle into the some other form, which results by decreasing of vehicle speed. The kinetic energy is transformed into the thermal energy, by using the dry friction effects and, after that, dissipated into the surroundings

The disc brake is a device for slowing or stopping the rotation of a wheel. A brake disc (or rotor) usually made of cast iron or ceramic composites (including carbon, Kevlar and silica), is connected to the wheel and/or the axle. To stop the wheel, friction material in the form of brake pads (mounted on 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.

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. In today's growing automotive market the competition for better performance vehicle in growing enormously. The racing fans involved will surely know the importance of a good brake system not only for safety but also for staying competitive As we area ware of the fact that races are won over split of a second therefore the capacity of the brake system to slow down quickly at turns or corners is very important The brakes designed for the purpose of racing need to have very high braking efficiency. The wear and tear of the pads or the cost is not of great concern to the manufacturer of the racing car brakes..

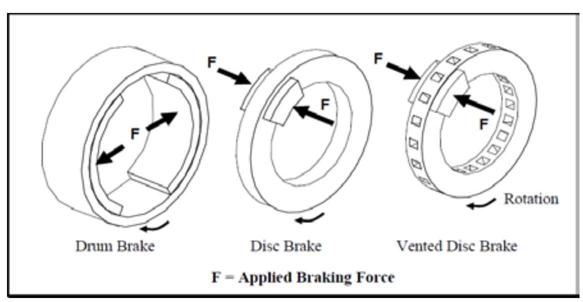
2. Vehicle Brakes

Vehicle braking is the most concentrated area of study while considering the automobile studies. Friction braking is the usual system in automotives. Different types of breakings are

2.1 Types of Friction Brakes

Two main types of automotive brakes exist, drum and disc. Drum brakes operate by pressing shoes (stator) radially outwards against a rotating drum (rotor), while disc brakes operate by axially compressing pads (stator) against a rotating disc (rotor) as shown in Figure 2.1.

A more advanced form of the disc brake is the ventilated or vented disc, where internal cooling is achieved by air flowing through radial passages or vanes in the disc.



2.2 Advantages of Disc over Drum

- The rubbing surfaces of the disc brake are exposed to the atmosphere providing better cooling and reducing the possibility of thermal failure (brake fade and brake fluid vaporization).

- In drum brakes, expansion of the drum at elevated temperatures will result in longer pedal travel and improper contact between the drum and shoes, whereas in disc brakes elevated temperatures cause an increase in disc thickness, with no adverse effect in braking.
- Disc brake adjustment is achieved automatically whereas drum brakes need to be adjusted as the friction material wears.
- Disc brakes are less sensitive to high temperatures and can operate safely at temperatures of up to 1000°C. Drum brakes due to their geometry and effects on their friction co-efficient, should not exceed 500-600°C,

3. Problems associated with disc brakes

If the temperatures reached in braking become too high, deterioration in braking may result, and in extreme conditions complete failure of the braking system can occur. It can be difficult to attribute thermal brake failure to motor vehicle accidents as normal braking operation may return to the vehicle when the temperatures return to below their critical level.

3.1 Brake Fade

Brake fade is a temporary loss of braking that occurs as a result of very high temperatures in the friction material. The high temperature reduces the coefficient of friction between the friction material and the rotor, and results in reduced braking effectiveness and ultimately failure. Generally fade is designed to occur at temperatures lower than the flame temperature of the friction material to reduce the possibility of fire at extreme temperatures. Normal braking will usually return when temperatures drop below their critical level.

3.2 Brake Fluid Vaporization

Most braking systems are hydraulically actuated, with the exception of heavy-duty trucking. If temperatures reached during braking exceed the boiling point of the hydraulic fluid then brake fluid vaporization will occur. A vapour lock will then form in the hydraulic circuit, and as gas is more compressible than liquid the pedal stroke is used to compress this gas without actuating the brakes. Brake fluid is hydroscopic causing it to absorb water from the atmosphere over time; this may result in a reduced boiling temperature of the fluid, Therefore it is usually recommended by vehicle manufacturers to replace brake fluid periodically.

3.3 Excessive Component Wear

High temperatures in the braking system can form thermal deformation of the rotors leading to uneven braking, accelerated wear and premature replacement. The life of the friction material is also temperature dependent, at higher temperatures chemical reactions in the friction material may cause a breakdown in its mechanical strength, which reduces braking effectiveness and causes rapid wear. The wear of frictional material is directly proportional to contact pressure, but exponentially related to temperature, therefore more rapid wear will occur at elevated temperatures

3.4 Thermal Judder

On application of the vehicles brakes, low frequency vibrations may occur, these vibrations can be felt by the driver as body shake, steering shake and in some cases an audible drone, This phenomenon is known as ‘judder’. Two types of judder exists; hot (or thermal judder) and cold judder. Cold judder is caused by uneven thickness of the rotor, known as disc thickness variation, this leads to deviations in contact pressure as the pads connect with the rotor. This results in uneven braking or brake torque variation. The second type, thermal judder, occurs at elevated temperatures, and is caused by thermal deformation of the rotor.

3.4 Dissipation of Heat from Disc Brakes

The rise in temperature of the brake disc in any braking operation will depend on a number of factors including the mass of the vehicle, the rate of retardation, and the duration of the braking event. In the case of short duration brake applications with low retardation, the rotor and friction material may absorb all of the thermal energy generated. As a result very little heat dissipation occurs as the temperature rise in the rotor is minimal. In extreme braking operations such as steep descents or repeated high speed brake applications, sufficient heat dissipation becomes critical to ensure reliable continued braking.

4. Convective Heat Transfer

Convection to the atmosphere must then be the primary means of heat dissipation from the brake rotor. Convection is governed by the expression:

$$Q=hA_s\,(Ts-T)$$

also know as Newton’s law of cooling.

Where:
Q = the rate of heat transfer (Watts),
h = the convection heat transfer coefficient (W/m^2 k),
A_s = the surface area of the rotor (m^2), and
Ts and T are the surface temperatures of the brake rotor and ambient air temperature respectively.

5. Aerodynamics of Vented Brake Discs

The need for increased cooling of disc brakes led to the development of vented rotor discs, however the advantages of vented discs over solid discs is the subject of some conjecture. The primary advantage of vented rotors is increased heat dissipation from internal pumping of air, however under slow speeds the pumping action of the vanes is minimal and only becomes pronounced as rotor speed increases,. At higher speeds the airflow flowing around the disc as a result of the forward movement of the vehicle, tends to prevent effective pumping of air through the vanes. Early work indicated that the heat dissipation from internal ventilation amounted to about one third of the total heat dissipation from the rotor, but suggested it was the larger surface area and not the pumping action that made the major contribution to cooling. While vented rotors do provide a larger surface area for heat dissipation, and extra airflow from the pumping effects of the vanes, it must be remembered that they will usually have a reduced mass than their equivalent solid rotor and therefore have less capacity to store thermal energy. Much of this work has involved attempts to increase the flow through internally ventilated rotors.

6. Alternate Ways To Minimize The Problems

To minimize the above problems in existing disc brake rotor, we should increase heat dissipation from the rotor and maximize the air flow through the disc brae ventes.

6.1 Disc Brake with Curved Vanes and Cross Drilled Holes

Many attempts have been made to improve the cooling ability of straight vane ventilated rotors. Zhang (1997) proposed a redesign of vented rotors to include an optimized number of flow passages, improved rounding on inlet vanes, and a long-short alternative vane configuration. This design contains twice the number of outlet vanes as inlet vanes, in order to reduced inlet blockages and guide to flow though the exit more easily. The configuration was modeled on CFD software and a 42% increase in flow through the vanes is claimed, however no experimental verification is given. A similar technique was used by to develop a rotor with three times the number of outlet vanes as inlet vanes, providing 35% more flow through the vanes when tested on a model in still air.

The cross drilled holes will produce more surface area to heat dissipation. Holes will produce better strength by avoiding unnecessary heating

7. Conclusions

The main contribution factors to effective automobile brake cooling were found to be vehicle velocity, disc material, wheel vent area, the thermal storage capacity of the rotor, and rotor type (solid or vented). The curved vanes in the rotor increase the centrifugal force of air. In curved vanes, the heat dissipation from the disc rotor is comparatively more than straight vane rotor. The

cross drilling of holes in the rotor improves the structural strength and at the same time it also reduces the temperature rise during braking.

References

[1] Ameer Fareed Basha Shaik, Ch.Lakshmi Srinivas **“**STRUCTURAL AND THERMAL ANALYSIS OF DISC BRAKE WITH AND WITHOUT CROSSDRILLED ROTOR OF RACE**”** International Journal of Advanced Engineering Research and Studies Vol. I/ Issue IV/July-Sept., 2012/39-43

[2] F.Talati and S.Jalalifar **“**INVESTIGATION OF HEAT TRANSFER PHENOMENA IN A VENTILATED DISC BRAKE ROTOR WITH STRAIGHT RADIAL ROUNDED VANES” Journal of applied science 3583-3592,2008

[3] Adam Adamowicz , Piotr Grzes**“**CONVECTIVE COOLING OF A DISC BRAKE DURING SINGLE BRAKING**”**Journal of engineering and technology vol.6 no.2 (2012).

[4] V.M.M.Thilak, R.Krishnaraj, Dr.M.Sakthivel, K.Kanthavel, Deepan Marudachalam M.G, R.Palani **“**TRANSIENT THERMAL AND STRUCTURAL ANALYSIS OF THE ROTOR DISC OF DISC BRAKE**”**International Journal of Scientific & Engineering Research Volume 2, Issue 8, August-2011

[5] Mohd Firdaus Abu Bakar, Muhd Ridzuan Mansor, Mohd Zaid Akop, Mohd Afzanizam Mohd Rosli, Mohd Azli Salim.“THERMAL ANALYSIS OF VENTILATED DISC BRAKE ROTOR FOR UTEM FORMULA VARSITY RACE CAR” Journal of Engineering and TechnologyVol. 2 June 2011.