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DEVELOPMENT AND INVESTIGATION OF FADE STOP BRAKE COOLER IN AUTOMOBILES

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Abstract

Several brakes which is used to stop the vehicles but the disc brake is a one of the braking mechanism which is used for slowing or stopping the rotation of a wheel under dynamic situation. A brake disc 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 caliper) is forced mechanically hydraulically, pneumatically or electromagnetically against both sides of the disc. Friction reasons the disc and attached wheel to gradual or stop. Brakes convert motion to warmness, and if the brakes get greater than ordinary, the pad emerges as less effective, the phenomenon is referred to as fade. Brake fade is caused by a buildup of warmth within the braking surfaces and the following modifications and reactions in the brake system additives and this will be reduced through cooling the friction elements efficaciously. The present work is focused on the developing a fade stop brake cooler for the disc brake by increasing the heat dissipation of brake pad for the vehicle Ashok Leyland DOST and testing it practically in the test track and to obtain a cooling curve diagram. The obtained cooling curve is compared with the cooling curve graph of the existing brake arrangement. The test is taken by using DAS2A, GRAPHTECH and MW100 testing equipment.

Key words: Brake fade, Brakes, Cooling curve, Friction, Performance.

1 Introduction

Braking is the mechanism in the vehicle which is used to slowing down and stopping the vehicle to rest in the shortest possible distance. Principle of braking system: While operating the braking system energy changes takes place that is the Kinetic Energy of moving vehicle is converted in to Heat Energy via friction. The cooling of the brakes dissipates the heat and the vehicle slows down. It's the First Law of Thermodynamics, sometimes known as the law of conservation of energy. This states that energy cannot be created nor destroyed; it can only be converted from one form to another. In the case of brakes, it is converted from kinetic energy to thermal energy Because of the configuration of the brake pads and rotor[1-2] in a disc brake, the location of the point of contact where the friction is generated also provides a mechanical moment to resist the turning motion of the rotor. Brakes are generally applied to rotating axles or wheels, but may also take other forms such as the surface of a moving fluid (flaps deployed into water or air).

Some vehicles use a combination of braking mechanisms, such as drag racing cars with both wheel brakes and a parachute, or airplanes with both wheel brakes and drag flaps raised into the air during landing. Since kinetic energy increases quadratic ally with velocity (K = mv2 / 2), an object moving at 10 m/s has 100 times as much energy as one of the same mass moving at 1m/s , and consequently the theoretical braking distance, when braking at the traction limit, is 100 times as long. In practice, fast vehicles usually have significant air drag, and energy lost to air drag rises quickly with speed [3].

Since the kinetic energy is converted into heat energy in the braking system a large amount of heat is produced in the system. In the disc brakes as the brake pads clamp the brake disc to stop the vehicle the kinetic energy of the brake rotor is converted it to heat energy and so heat is generated in the brake disc. Due to this is a thermal stress is produced in the brake disc which may led to the failure or breaking of the brake disc. In order to avoid the thermal stress in the brake rotors the rotor has an integral vent which, during rotation, moves ambient temperature air through the rotor as a means to cool it down [4-5].

The brake pads, however, have no such mechanism and cooling is primarily achieved through contact with the rotor and contact with the caliper piston. But cooling through contact with the rotor may not always be effective. It is therefore not surprising that it is possible to get even high temperature brake fluid to boil. The Fade Stop Brake Cooler is an inexpensive aftermarket accessory that fits between the brake pad backing plate and the caliper piston. The stainless steel of the novel metal composite prevents deformation of the ductile copper that is providing a thermally conductive path from the interface to a heat sink located externally to the caliper [6].

2 Methods of brake fade

Vehicle braking system fade, or brake fade, is the reduction in stopping power that can occur after repeated or sustained application of the brakes, especially in high load or high speed conditions. Brake fade can be a factor in any vehicle that utilizes friction brakingsystem.including automobiles, trucks, motorcycles, airplanes, and even bicycles. Brake fade is caused by a buildup of heat in the braking surfaces and the subsequent changes and reactions in the brake system components and can be experienced with both drum brakes and disc brakes. Loss of stopping power, or fade, can be caused by friction fade, mechanical fade, or fluid fade. Brake fade can be significantly reduced by appropriate equipment and materials design and selection, as well as good cooling. Brake fade occurs most often during high performance driving or when going down a long, steep hill. Owing to their configuration fade is more prevalent in drum brakes. Disc brakes are much more resistant to brake fade because the heat can be vented away from the rotor and pads more easily, and have come to be a standard feature in front brakes for most vehicles [7-8].

a) Causes of Brake Fade

The reduction of friction termed brake fade is caused when the temperature reaches the "knee point" on the temperature-friction curve. [All brake lining is cured under mechanical pressure following a heating & cooling curve, heating the friction material up to 450°F to "cure" (cross-link) the phenolic resin thermoset polymers: There is no melting of the binding resins, because phenolic resins are thermoset, not thermoplastic] In this form of fade, the brake pedal feels firm but there is reduced stopping ability. Fade can also be caused by the brake fluid boiling, with attendant release of compressible gases. In this type of fade, the brake pedal feels "spongy". This condition is worsened when there are contaminants in the fluid, such as water, which most types of brake fluids are prone to absorbing to varying degrees. For this reason brake fluid replacement is standard maintenance.

Brake fade failures can cascade. For example, a typical 5-axle truck/trailer combination has 10 brakes. If one brake fades, brake load is transferred to the remaining 9 brakes, causing them to work harder, get hotter, and thus fade more. Where fade is non-uniform, fade may cause a vehicle to swerve. Because of this, heavy vehicles often use disproportionately weak brakes on steered a wheel, which hurts the stopping distance and causes brakes on non-steered wheels to work harder, worsening fade. An advantage of low fade brakes such as disc brakes is steered wheels can do more braking without causing brake steer.

After cooling, faded brakes usually perform as well as before, with no visible change to the brake shoes and/or pads. However if the brakes have been excessively hot for a prolonged period of time, glazing can occur on both of the friction linings of the shoes and pads. When this happens, the contacting surfaces of the linings will have a smooth, shiny appearance, and will not perform as efficiently to slow the vehicle under braking. This glazing can be easily removed by either gently using emery paper on them, or by driving the vehicle carefully whilst implementing light use of the brakes for several miles.

Long dual-tire skid marks on highways, made by trucks with drum brakes, are visible examples of non-linearity between brake response and pedal pressure. Large trucks still use drum brakes because they are economical and fit easily where an equivalent disc brake does not. More recently disc brakes for trucks have been promoted listing features such as no fade, possible because they have no self-assist.

3 Fade stop brake cooler

The rotor has an integral vent which, during rotation, moves ambient temperature air through the rotor as a means to cool it down. The brake pads, however, have no such mechanism and cooling is primarily achieved through contact with the rotor and contact with the caliper piston. Judging from the glowing rotor and the brake pad fire in, it is clear that cooling through contact with the rotor may not always be effective. It is therefore not surprising that it is possible to get even high temperature brake fluid to boil. The Fade Stop Brake Cooler is an inexpensive aftermarket accessory that fits between the brake pad backing plate and the caliper piston .it consists of a stainless steel plate and a copper plate attached together and a copper fin like structure which extends from the copper plate. The stainless steel of the novel metal composite prevents deformation of the ductile copper that is providing a thermally conductive path from the interface to a heat sink located externally to the caliper.. While the gold plated copper ducts are currently bent away from the brake pad backing plate, upon installation they will fit into the spaces between the stainless steel fingers. In order to monitor the temperature of the brake pad backing plate and caliper piston interface with and without the FSBC (see Fig.1) it was necessary to construct two custom thermocouple assemblies that would fit onto the end of the caliper pistons.

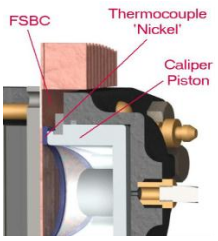


Fig1: Diagram of Fade stop brake cooler

a) FSBC In the Dost

For practical mounting purposes the FSBC for dost is made as two halves. One half fits between the piston and the brake pad (see Fig.2) (in the inner pad) the another half is made as a structure with fin like structures for the purpose of heat dissipation (see Fig.3&4). The two halves are fixed together by means of screw. The 'lower part or the slotted structure is placed between the pad and the piston and the projection from that part is screwed with the projection from the fin like structure, and this structure is placed on the caliper (see Fig.5).

Fig 2: The Slotted Part Which Fits Between the Piston and Brake Pad

Fig3: The Fin like Structure in FSBC

Fig4: The Assembled View of FSBC

Fig5: FSBC Fitted With Brake Caliper In Dost

4 Braking cooling test

The brake test is the performance test conducted on brakes for the measurement of efficiency and the condition of brakes. The brake test is conducted mainly for the measurement of temperature of brake disc and brake pad. The temperature is measured by fixing a thermocouple to the brake disc and thermocouple fitted brake pads are installed in the vehicle.

The output of the thermocouple is connected to GRAPHTECH test equipment.

The distance measured is by using DAS2 instrument which is then connected to GRAPHTECH to obtain the output. The brake test is conducted in the test track by following some standard procedures summarized in Table 1.

Initial braking speed	100 km/h
Final speed	0 km/h
Deceleration	4.5 m/s2
Interval	35 sec
Rotor temperature	550-600 °C
Starting measurement temp	550 °C
Ending measurement temp	250 °C

Table 1: The brake test is conducted in the test track.

Procedure of brake cooling test

a) **Brake Heating:**

Initially vehicle is made to travel at speed of 80kmph from 0kmph after reaching the point pedal effort of 16+ 2 kg is applied at the point for braking. And again the speed is raised to 80kmph and the pedal effort is applied for braking. This increases the temperature of the disc and the temperature is made to reach at a point to 500•c. After the temperature is attained the cooling process is taken.

b) **Brake Cooling**

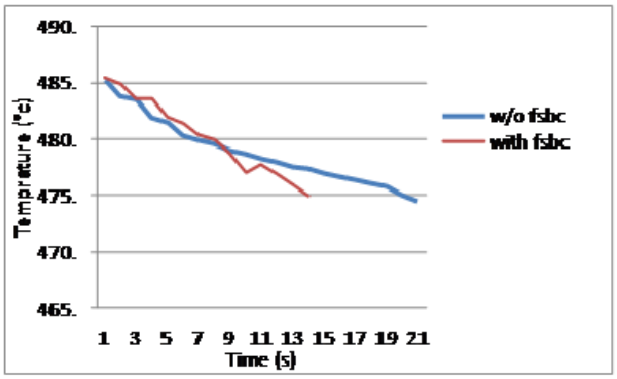
During brake cooling process the vehicle is made to run towards a certain distance with the temperature and time constant. The vehicle is made to run at a

constant speed of 50Kmph. The cooling rate and the time for cooling are recorded in comparison to the other disc. These temperatures are received from the thermocouple and the force applied is measured using pedal effort sensor, the distance is measuring using l350 sensor. These readings are collected or obtained in GRAPHTECH instrument which is then compiled with respect to requirements. The temperature difference in both the disk is compared and the readings are tabulated by keeping the time and distance constant with respect to the direction of flow (upward or downward travel).

c) **Cooling curves**

The following graphs show the details of test taken after the removal of the dust cover in comparison to FSBC.

The graphs of up cooling and down cooling are plotted based on the data collected. The experiment is carried out multiple times also considering the worse of the worst conditions. The test was conducted on the WABCO test track. The test was conducted for a very generous braking period and at different forces for different speeds. The test results were quite favorable and very practical.



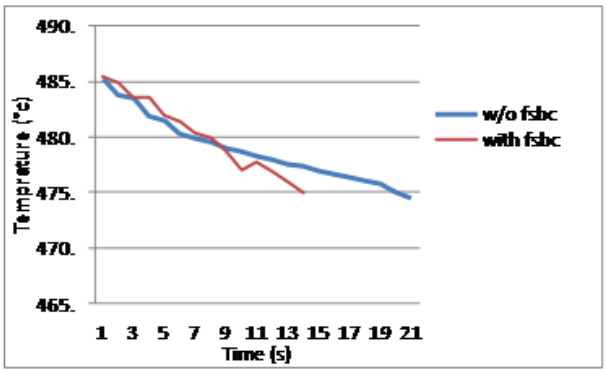


Fig6: Cooling rate after reaching the required temperature between dost and FSBC during UP COOLING & Down cooling.

4 Results and Discussion

	Up cooling (with out FSBC)	Up cooling (with FSBC)	Down cooling (without FSBC)	Down cooling (with FSBC)
Max Temp Reached °c	512	511	485.5	485
Cooling Index	0.0015	0.0022	0.0010	0.0019

From the above result it is clearly understood that there is a difference in the cooling index which shows that the heat dissipation is efficient. In the above shown table, in the up cooling test result the cooling index was 1.5*10-3 and after fixing the FSBC the cooling index was found to be 2.2*10-3 which shows that the cooling has become efficient after fixing the FSBC. In the same way during the down cooling test the cooling index was found to be 1.0*10-3 and the test results after fixing the FSBC shows the cooling index to be 1.9*10-3. This in turn proves that the cooling is efficient after fixing the FSBC to the brake pads .After fixing the FSBC the heat gets transferred from the brake pad to the slots in the FSBC and then it is conducted to the fins fitted to the FSBC. From the fins the heat is being taken away by the air passing through the fins which makes the cooling efficient.

4 Conclusions

On observing the readings from the test taken without fixing the FSBC the brake disc seems to get cooled slowly and the cooling index is also found to have lesser value of 0.002 during up cooling and 0.002 during the down cooling.

After fixing the FSBC to the brake pad of the vehicle, the brake test results shows the increased rate of cooling and the cooling index has increased to 0.0022 during up cooling and 0.0019 during down cooling.

On observing these readings FSBC seems to be having better cooling index when compared to the existing configuration. Due to this the brake pad will have lesser fade and improved performance at high temperature braking.

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