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DESIGN AND ANALYSIS OF BRAKE PADS FOR HYDRAULIC CIRCUIT

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ABSTRACT

Brake pads are one of the most important component in the automobile braking system. Brake pads are the steel backing plates with frictional material bound to the surfaces that faces the disc brake rotor. These are located within the brake calipers which presses the rotating disc and slows & stops the vehicle. As these are continuous contact items, they need to be replaced. The main aim of our project is to Design and Analyze the Brake Pads for Hydraulic Circuit. This involves designing brake pads as per the market model and Selection of suitable material which can withstand the high temperatures and less wear rate.

For high performance use, a compound that works at low moderate temperatures with good wear characteristics, low noise, and minimal dust is recommended. The frictional performance of the brake pads depends on coefficient of friction.

Keywords:

I.INTRODUCTION: BRAKES

Brakes are one of the important components in the design of the vehicle and it falls under the category of safety system where these are used to reduce the speed when required and to panic stop. These are also necessary to avoid sudden collisions of vehicle with other another vehicle or obstacle.

1.1TYPES OF BRAKES:

a)Disc Brake:

A disc brake is a type of brake that uses calipers to squeeze pair of pads against a disc in order to create friction that retards the rotation of a shaft, such as a vehicle axle, either to reduce its rotational speed or to hold it stationary. The energy of motion is converted into waste heat which must disperse. Hydraulic disc brakes are the most commonly used form of brake for motor vehicles but the principles of a disc brake are applicable to almost any rotating shaft.

Disc brakes offer better stopping performance because the disc is more readily cooled. As a consequence discs are less prone to the brake fade caused when brake components overheat. Disc brakes also recover more quickly from immersion (wet brakes are less effective than dry ones).

By contrast, a disc brake has no self-servo effect and its braking force is always proportional to the pressure placed on the brake pad by the braking system via any brake servo, braking pedal, or lever. This tends to give the driver better "feel" and helps to avoid impending lockup. Drums are also prone to "bell mouthing" and trap worn lining material within the assembly, both causes of various braking problems.

The brake disc is usually made of cast iron, but may in some cases be made of composites such as reinforced carbon–carbon or ceramic matrix composites. This is connected to the wheel and or axle. To retard the wheel, friction material in the form of brake pads, mounted on the brake caliper, is forced mechanically, hydraulically, pneumaticallyor electromagnetically against both sides of the disc. Friction causes the disc and attached wheel to slow or stop.

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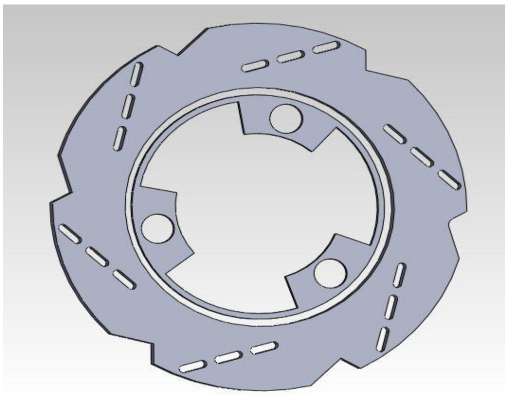

Fig 1.1 Brake Pad

b)Drum Brake:

A drum brake is a brake that uses friction caused by a set of shoes or pads that press outward against a rotating cylinder-shaped part called a brake drum.The term drum brake usually means a brake in which shoes press on the inner surface of the drum. When shoes press on the outside of the drum, it is usually called a clasp brake. Where the drum is pinched between two shoes, similar to conventional disc brake, it is sometimes called a pinch drum brake, though such brakes are relatively rare. A related type called a band brake uses a flexible belt or "band" wrapping around the outside of a drum.

Fig 1.2 Drum Brake

1.2 INTRODUCTION TO BRAKE PADS:

Brake pads are 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 disc brake rotor. Brake pads convert the kinetic energy of the car to thermal energy by friction. Two brake pads are contained in the brake calipers 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

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and lights a warning light when the brake pad gets thin. More expensive cars may use an electronic sensor.

Fig 1.2.1 Brake pads

Maintaining the brakes is one of the most important safety features for any vehicle owner and is key to a vehicles upkeep for long term ownership. Unfortunately brake maintenance is often overlooked by drivers. Maintaining the cars brake system can help to prevent costly repairs in the long run, and can keep the car in the best form to avoid a collision. In order to maintain a vehicles brake system, you must pay close attention to the condition of car's brake pads. As a general rule, the more the vehicle owner drives, the more wear on the brake pads, and therefore the shorter the lifespan of the brake pads. Patchway Auto parts have created this article to let a driver know that the current brake pads need to be replaced with new brake pads. Here are 6 signs that helps you to identify when they need to replace their current brake pads with new ones.

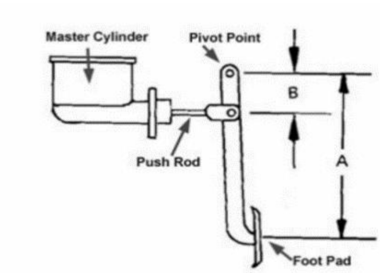
II DESIGN

SOLIDWORKS design software is as simple as it is powerful – enabling any company to bring its vision to life and capture global markets. SOLIDWORKS solutions focus on the way you work every day, with an intuitive, integrated 3D design environment that covers all aspects of product development and helps maximize your design and engineering productivity. Over 2 million designers and engineers worldwide use SOLIDWORKS to bring designs to life—from the coolest gadgets to innovations for a better tomorrow and lights a warning light when the brake pad gets thin. More expensive cars may use an electronic sensor.

III CALCULATION

Force on each component:

1.Brake pedal:



1. Multiplies the force applied by the driver's force on the master cylinder piston.
2. Activates a piston to displace hydraulic fluid from the master cylinder.
3. The force output of the brake pedal is determined by the following variables.

Total force =drivers effort*(A/B), $F_{bp} = F_d$ *(A/B), A/B = pedal ratio, F_{bp} = total pedal force,F_d = drivers effort
Here the pedal ratio of our vehicle is 5:1

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Here F_d = 20kg, F_d = 196.2N, F_{bp} = 196.2*(5/1), F_{bp} = 981N

2. Pressure in Master Cylinder:

According to Pascal's law, the force generated by the brake pedal will be same transmitted to the master cylinder. Fb p^Pmc = $_{Amc}$ Where, P_{mc} = pressure in master cylinder, A_{mc} = area of the master cylinder, A_{mc} = $^{\pi}{}_4$ (dmc)^2 = 3.14*10^{-4}m^2, P_{mc}= 3.12*10^6N/m^2

3.Brake fluid, brake pipes and hoses:

According to Pascal's law intensity of pressure transmitted throughout the fluid will be constant, unless there are no losses. So the pressure transmitted to the calipers will be equal to that of master cylinder.

Pcal = Pmc P_{cal} = 3.12*10^6N/m^2

4. Calipers: Converts hydraulic fluid pressure from pipes into linear mechanical force

Fcal = Pcal*Acal, A_{cal} = $^{\pi}{}_4$ * (0.0254)^2 = 5.07*10^{-4}, F_{cal} = (3.12*10^6) * 2 * 5.07 * 10^{-4}=3163.68N

5.Clamping force: The disc brakes use the clamping force equal to twice the linear mechanical force received.

Fclamp = Fcal*2, F_{clamp} = clamping force generated by the caliper, F_{clamp} = 3163.68 *2= 6327.36N

6. Brake pads: Brake pads generate frictional forces to oppose the rotation of kinetic force of the spinning rotor assembly.

Ffriction = Fclamp * µbp,$F_{friction}$= the frictional force generated by the brake pads on the rotor μ_{bp} = coefficient of friction between the brake pads and the rotor $F_{friction}$= 6327.36 * 0.6=3796.41N

7.The rotor: This torque is related to the brake pad frictional force as follows: Tr = Ffriction* Reff

Where, T_r = torque generated by the Rotor, R_{eff} = the effective radius of the rotor=$_2^D$ - $^d{}_2$

D = diameter of the rotor,d= diameter of the caliper piston=87.3mm,T_r = 3796.41 * 0.0873,T_r = 331.42Nm

The torque will be constant throughout the entire rotating assembly as follows:

T_r = T_w = T_t = 331.42Nm,T_w= the torque found in the wheel,T_t=the torque found in the tyre

8.The Tire: The tire will develop force in reaction to torque of rotor or tire.

The amount of force on tire will depend on tire's characteristics F_{tire} = $_{Re}{}^{Tt}$

F_{tire}= force reacted between the tire and the ground R_e= effective roll radius of the loaded tire =0.96*radius of the tire,F_{tire} = $^{331.42}{}_{0.2804}$,F_{tire} = 1181.95N,Total force on the tire can be obtained by multiplying the force on tire with 4

Ftotal = Ftire*4,F_{total} = total braking force reacted between the vehicle and ground=4727.81N

9.Deceleration of the vehicle in motion: The negative acceleration (deceleration) of the vehicle will be equal to D_v = $^{Ftotal}{}_{mv}$, M_v = mass of the vehicle with driver=17.51m/s^2

10.Stopping distance: For a vehicle experiencing a linear deceleration, the stopping distance of the vehicle can be calculated as follows: S_d = $V_v{}^2$/ (2*a_v), S_d = stopping distance of the vehicle, V_v= 40kmph = 11.11m/s

S_d = (11.11)^2/ (2*17.51)=3.52m

11.Stopping time: Theoretically stopping time can be calculated as follows:S_t = 2S_d/ (v+v_0),S_t = stopping time S_d = stopping distance,V_0 = initial velocity (m/s),V = final velocity (m/s),S_t = 0.63sec

12. Temperature = 36^o degrees

Iteration table:

Drivers effort	Stopping distance
13kg	5.41
14kg	5.04
15kg	4.70
16kg	4.42
17kg	4.13
20kg	3.52

Table 2. Stopping distance

Specifications	Value
Mass of the vehicle with driver	270 kg
Max. Speed of the vehicle	40kmph
Pedal ratio	5:1
Diameter of the master cylinder/caliper piston	20 mm/25.4 mm
Diameter of the rotor	200mm

Table 3. Specifications

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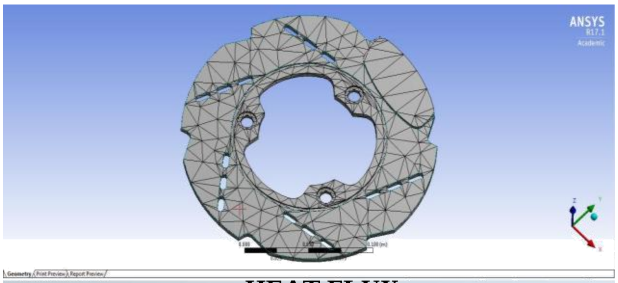
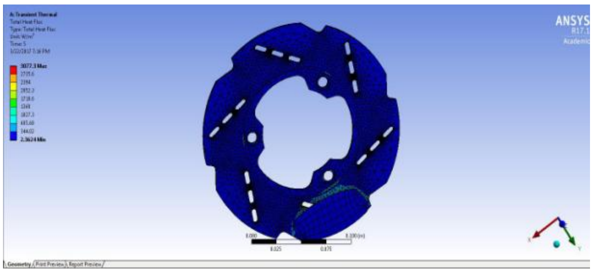
IV ANALYSIS:

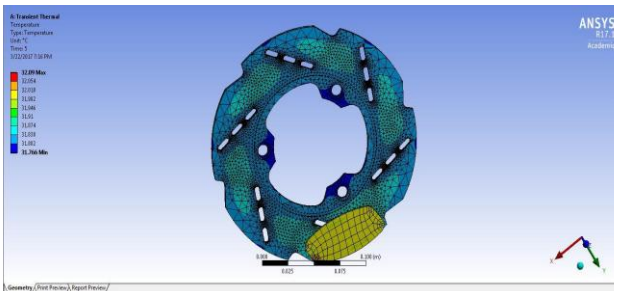
MESHING



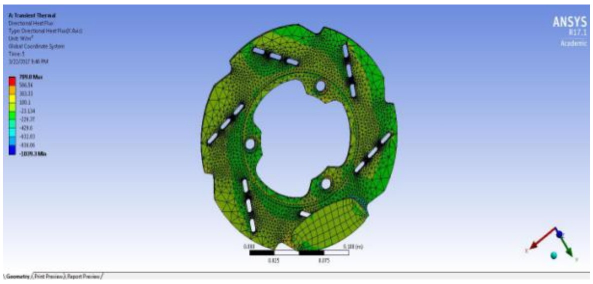
THERMAL ANALYSIS: CERAMIC (TEMPERATURE)



HEAT FLUX

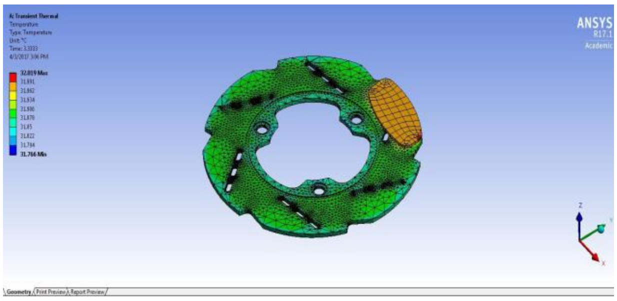


DIRECTION OF HEAT FLUX

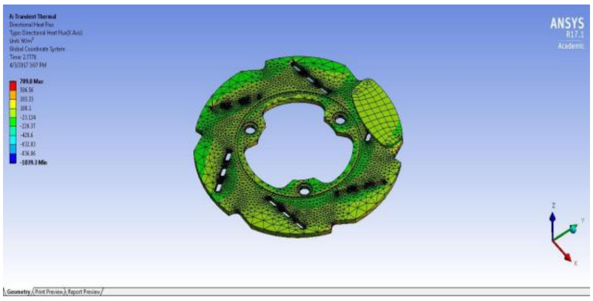


4.1 ASBESTOS

TEMPERATURE



HEAT FLUX



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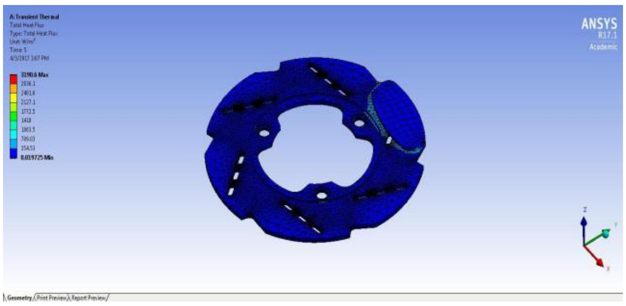

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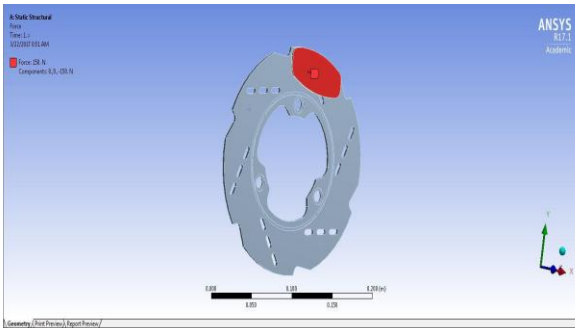
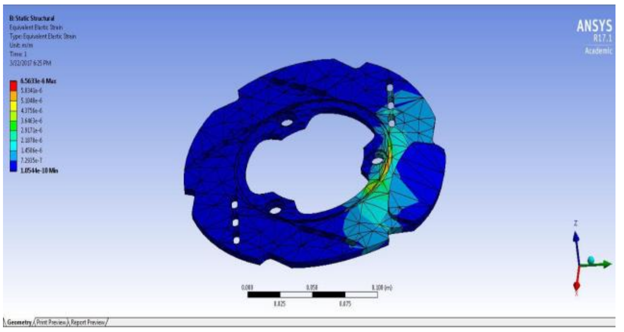
4.2 STATIC ANALYSIS:

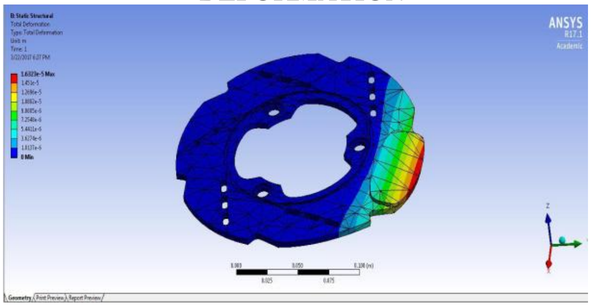
CERAMIC



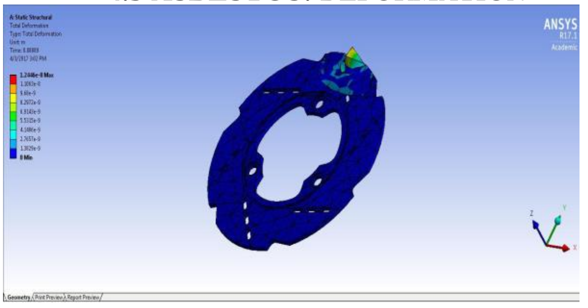
STRAIN



DEFORMATION



4.3 ASBESTOS: DEFORMATION



V. CONCLUSION:

Brake pads are designed as per the standard dimensions and analysis is done by changing the material which best suits the required properties. In analysis, asbestos was compared with ceramic material. Based on analysis ceramic is the best material which has better heat dissipation capacity and environmental friendly material compared with asbestos. The only disadvantage with ceramic material is expensive compared to asbestos.

VI. FUTURE SCOPE OF THE PROJECT

Future scope of the project is, the designed brake pads can be manufactured and experimented practically.

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