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Preparation of Brake Disc Setup and Analyzing Its Dynamic and Thermal Characteristics

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Abstract: *Braking is the process which converts kinetic energy of the vehicle into mechanical energy which must be disc brake is the device for deaccelerating or stopping the rotation of wheel. A brake disk usually made up of cast iron or ceramic composites is connected to wheel or the axel friction material in form of brake pads (mounted on a device called brake caliper) is forced mechanically, hydraulically or pneumatically or electromagnetically against both sides of disc to stop wheel the present research basically deals with modeling and analysis of solid and ventilated disc brake using pro e or ANSYS . Finite element (FE)models of the brake disc are created using Pro–E which is based on finite element method in the research analysis is preferred in order to find strength of the disc brake. In structural analysis disc brake the displacement ultimate stress limit is found and the thermal flux is calculated.*

Keywords: *Disc Brake,CATIA, ANSYS, Thermal Flux, Break Torque, Disc Brake Rotor*

I. Introduction

In Breaking system there are various problems occurred such as a response of stopping of vehicle, Heating of Brake shoe which causes thermal stresses in brake shoe, Friction & wear of surfaces which causes the worn out of friction surfaces. To overcome such a problem in conventional braking system disc brake system is developed. Which gives better breaking effect, stopping response but other than this advantages some disadvantages also occurred in disc brake system due to friction which produces squeal, thermal stresses, & worn out of rotor surfaces so braking efficiency will be affected. So in to avoid this we must find some material which gives less wear than now a day's rotor & also which produces a less temperature and best alternative to conventional one. By studying various literatures available with us we found that the change in material of disc brake is possible to reduce the wear & temperature.

1. Brake

A brake is a mechanicaldevice which inhibits motion. Its opposite component is a clutch. Brake pedal slows a car to a stop. When you depress your brake pedal, your car transmits the force from your foot to its brakes through a fluid. Since the actual brakes require a much greater force than you could apply with your leg, your car must also multiply the force of your foot. The brakes transmit the force to the tires using friction, and the tires transmit that force to the road using friction also. Almost all wheeled vehicles have a brake of some sort. Even baggage carts and shopping carts may have them for use on a moving ramp. Most fixed-wing aircraft are fitted with wheel brakes on the undercarriage. Some aircraft also feature air brakes designed to reduce their speed in flight. Friction brakes on automobiles store braking heat in the drum brake or disc brake while braking then conduct it to the air gradually. When traveling downhill some vehicles can use their engines to brake. Since major disc brake components are exposed to air, heat generated during braking can dissipate efficiently, which offers high resistance to brake fade (heat-induced degradation of braking performance). In addition, since water is flung off the rotor due to its rotation, the phenomenon of water fade (significant loss of braking performance caused by buildup of water on the disc) becomes less likely to occur. This type of disc brake has pistons on both sides of the brake rotor, and there are no moving parts in the caliper assembly other than the pistons themselves. This type of caliper provides very even pressure distribution between pads and rotor providing better braking performance, especially under severe braking conditions.

As vehicles have developed over the years the technology required to stop these vehicles has also undergone a massive evolution. The first type of brakes were external type brakes used on horse carriages which were actuated by means of aLever which brought a rubber pads in contact to axle. These were followed by internal brakes using drums or disks attached to each wheel. This paper sketches a history of these braking systems. It also discusses about the present trendsand prospects in the world of brakes.

Talking about the present trends in braking systems there are two types of them that are predominantly being used on all vehicles, be it two, three or four-wheeler vehicles. Disc brakes and drum brakes. While drum brakes are the cheaper of the two, they tend to wear more and have a high cost of maintenance. Thus, they have a lower economic as well as overall efficiency. Disc brakes on the other hand have become synonyms for exceptional braking power, vehicles with disc.

1.1Types of Brakes
Drum and Disc Brakes
Air Brakes
Electromagnetic Brake
Vacuum Brakes
Regenerative Brake
Aerodynamic Braking

II. Brake Test Setup

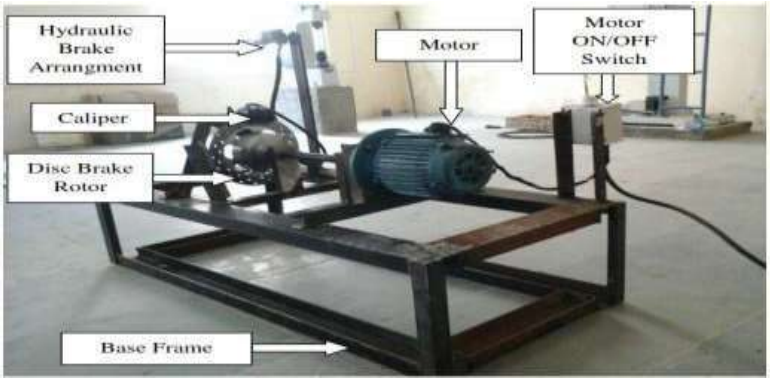

Fig: 2.1 Brake Setup

Brake is an essential component of moving vehicle, in which break is used for stopping or slowing down the vehicle. In vehicle various kinds of braking systems are used such as drum brake, disc brake, band brake, which is operated by Pneumatically, Hydraulically, electrically, mechanically or by either combination of two means. The disc brake is loaded with various stresses, wear & squeal, in this study we are going to find the wear rate of disc brake rotor for different materials to find the best suitable alternative material. We are performing experimentation on disc brake rotor to obtain the Results for five different material, the wear rate is tested by using pin-on-disc machine. And temperature produces at surface is obtain from the test setup available. Then same disc modelled by using Catia & analyzed for each parameter by using Ansys. And then results are compared to obtain the results.

III. Purpose

Main purpose of the brake disk setup is to analyze the efficiency of a respective brake system by using parameters such as (heat dissipation rate, braking efficiency etc) and based on the results obtained, comparing it with standardized data. Then based on comparison determining the efficiency of the respective braking system.
Hold a currency coin between a U-shape that you create with your thumb and index finger. Now imagine this illustration as a disc brake assembly, where the currency coin is acted upon by an imaginary force and rotates like the rotor or disc which is attached to the wheel of a motorcycle, the U-shape created by your digits is the caliper, the part of your fingers holding the coin are the brake pads, and the muscle force used to apply pressure on the coin is the hydraulic force in a brakingsystem which makes the whole thing work. Since we now have an overview of how a disc brake works.

IV. Thermal Analysis

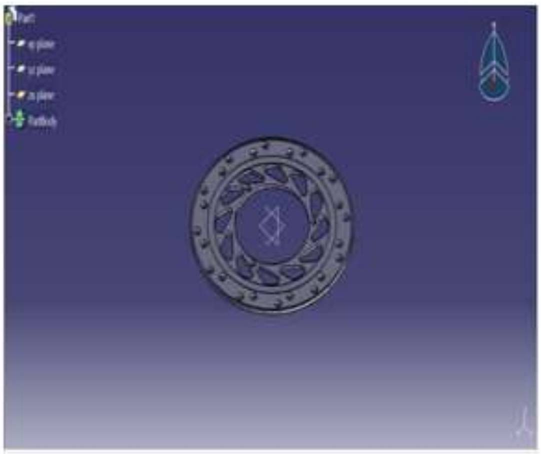

Fig : CAD Model (a)

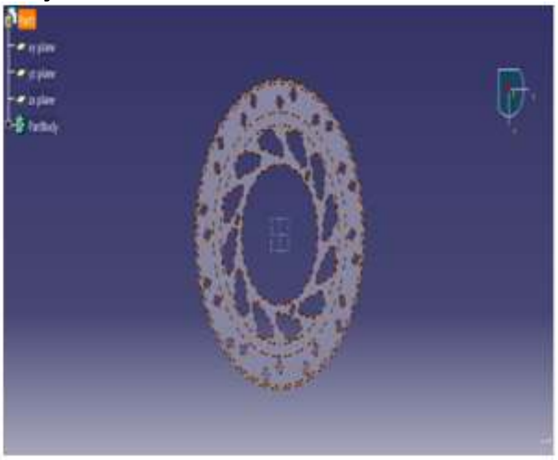

Fig : CAD Model (b)

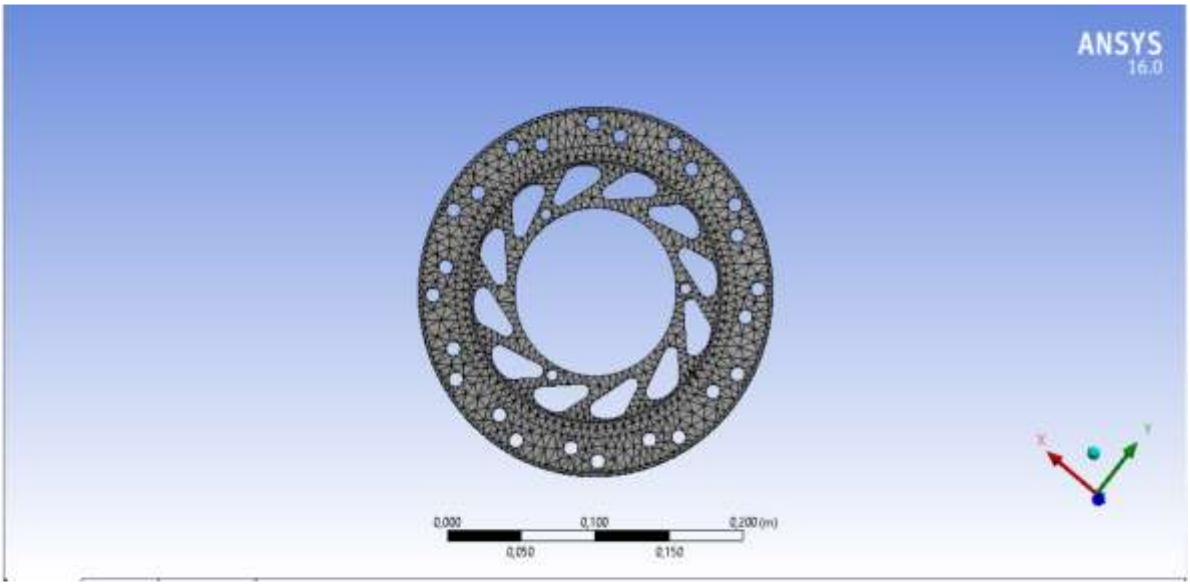

Fig : Disc after Meshing

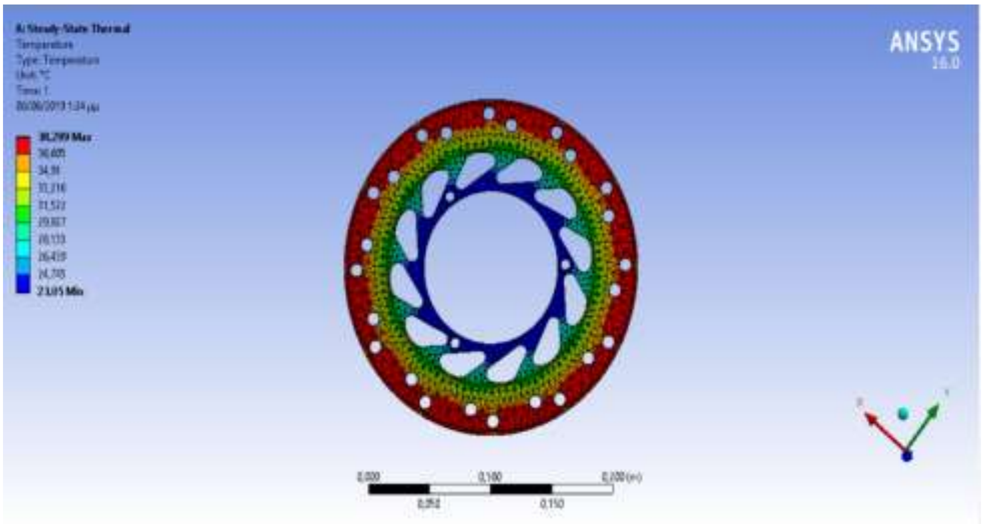

Fig : Temperature Analysis

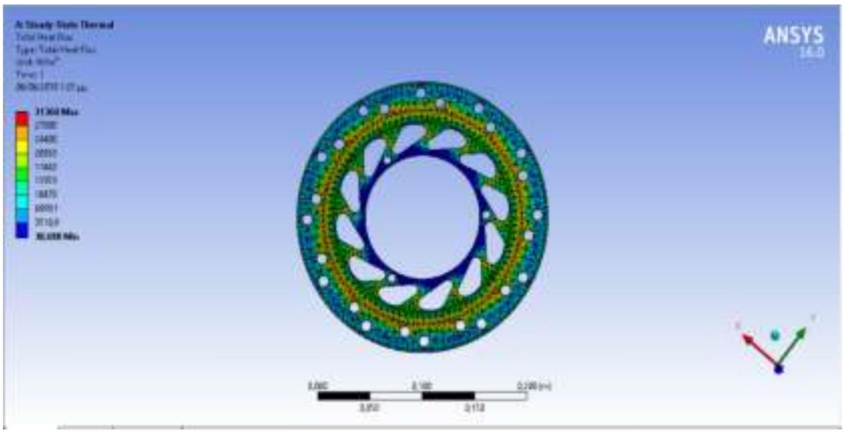

Fig: Heat Flux Analysis

V. Sample Calculation

Measuring terms

1. Initial brake speed
2. Paddle application force
3. Stopping distance
4. Deviation from length
5. Braking torque
6. Stopping time

Formulas:

$\dot{\omega} = (2\pi n) / 60$

Linear Speed $(V)=r*\dot{\omega}$ ……. (I)

Where,

V= Speed (m/s)

r = Radius of disc (m)

n = Speed in R.P.M

$\dot{\omega}$ = Angular speed

Experimental Values

r = 0.12 m

n = 150.41 R.P.M

Stopping Time (t) = 0.1 sec

On substituting values in equation (I)

V = 0.12*150.41

V = 18.05 m/s

Stopping Distance (s)= V*t

= 18.05*0.1

= 1.805 m

Braking Torque (T)

T = μ*p*π *(D)^2*Rm*N*(1/4) ………. (II)

T = Breaking Torque

μ = coefficient of friction

p = Brake Pressure

D = Brake Actuator Diameter

Rm = Mean Radius

N = No. Of Pads Brake

Ri = Inner Radius of Disc

Ro = Outter Radius of Disc

Experimental Value

μ = **0.5** for cast iron

N = 2

D = 0.1 m

Ri = 0.06 m

Ro = 0.12 m

Sol:

Rm = (Ri + Ro) / 2

= (0.06 + 0.16) / 2

= 0.09 m

P = F / A

= 20.5 / {2*(0.02*0.05)}

= 10290 N/m^2

T = μ*p*π *(D)^2*Rm*N*(1/4)

= (0.5*π*10290*0.01^2*0.09*2) / (4)

= 0.0727 Nm

Disc	Speed	Angular Velocity(□)	Velocity (m/s)	Peddle Force	Stopping Distance (m)	Braking Torque (Nm)
Disc 1	n1 = 1435	ὠ1 = 150.27	V = 18.03	19.6 N	1.803	0.0692
	n2 = 1090	ὠ2 =114.14	V = 13.6	20.58 N	1.36	0.0727
	n3 = 745	ὠ3 =78.08	V = 9.36	23.52 N	0.936	0.0831
Disc 2	n1 = 1420	ὠ1 = 148.7	V = 17.84	19 N	1.784	0.06528
	n2 = 1016	ὠ2 =106.39	V = 12.76	20.410 N	1.276	0.07013
	n3 = 720	ὠ3 = 75.39	V = 9.09	22.89 N	0.909	0.0786
Disc 3	n1 = 1423	ὠ1 = 149.01	V = 17.18	16.66 N	1.718	0.037
	n2 = 1040	ὠ2 =108.9	V = 13.06	15.88 N	1.306	0.035
	n3 = 732	ὠ3 = 76.65	V = 9.19	15.68 N	0.919	0.035

Table : Calculation Table

VI. Remarks and Conclusion

6.1 Remarks

- As speed increases torque decreases.
- As speed increases stopping distance at which the wheel will stop increases.

6.2 Conclusion

- During the tests the heat decapitated due to heat flow velocity it is not considered, it may affect the result.
- The same testing can be used for light four-wheeler vehicle with few modifications.

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