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INBOARD BRAKING SYSTEM

Mr. Rahul Naval Baviskar*1, Dr. Arvind S. Kondekar*2, Mr. Nandkumar S. Swami*3, Mrs. Swati A. Naik*4

*1B.E. Mechanical Engineering, Lecturer At Dr. D.Y. Patil Pratishthan's, Y.B. Patil Polytechnic, Akurdi, Pune, India.

*2Ph.D., Mechanical, Principal At Dr. D.Y. Patil Pratishthan's, Y.B. Patil Polytechnic, Akurdi, Pune, India.

*3M.Tech, Machine Design, HOD, Mechanical Engineering At Dr. D.Y. Patil Pratishthan's, Y.B. Patil Polytechnic, Akurdi, Pune, India.

*4M.Tech, Machine Design, Mechanical Engineering, Lecturer At Dr. D.Y. Patil Pratishthan's, Y.B. Patil Polytechnic, Akurdi, Pune, India.

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ABSTRACT

In this paper, we the authors explained the inboard braking system with calculations for Go-kart Vehicle. An inboard brake is an automobile technology wherein the disc brakes are mounted on the chassis of the vehicle, rather than directly on the wheel hubs. Its main advantages are twofold: a reduction in the unsprung weight of the wheel hubs, as this no longer includes the brake discs and calipers; and braking torque is applied directly to the chassis, rather than being transferred to it through the suspension arms.

Keywords: Analysis, Inboard, Brakes, Calculations, Go-Karts.

I. INTRODUCTION

An inboard braking system is an automobile technology wherein the disc brakes are mounted on the chassis of the vehicle, rather than directly on the wheel hubs. The main advantages are twofold: a reduction in the unstrung weight of the wheel hubs, as this no longer includes the brake discs and calipers; also, braking torque applies directly to the chassis, rather than being taken through the suspension arms.

Inboard brakes are fitted to a driven axle of the car, as they require a drive shaft to link the wheel to the brake. Most have thus been used for rear-wheel drive cars, although four-wheel drive and some front-wheel drives have also used them.

II. METHODOLOGY

Design of calculations of Inboard Braking System:

Selection of Brakes:

We are using disc brake for rear wheel considering the respective advantages, availability, and their limitations. The following reasons support the selection of disc brake for the rear wheels.

- Disc brake contributes for reduction in overall weight of the vehicle.
- More braking torque needs to be generated by the Rear brake even after weight transfer, because the single brake has to manage the braking torque requirement of the entire rear driveshaft

Brake Caliper:

For achieving a better braking efficiency and to improve the vehicle braking effect we have opted to use double piston single calipers for all rear wheels

Master Cylinder:

The master cylinder piston diameter that was calculated is the maximum possible diameter that can be used for safe braking. The team decided to use a master cylinder with 10mm piston diameter as it can provide better braking force and is also commonly found on bikes.

Brake Fluid (Dot 4):

DOT = Department Of Transportation

DOT 4 equivalent SAE1704, ISO4925, class4

Constituents: modified Glycol Ester / Borate Ester

Properties of Brake Fluid:

Very high Temperature Performance: High temperature resistance provides superior boiling point and high vapour lock temperature.

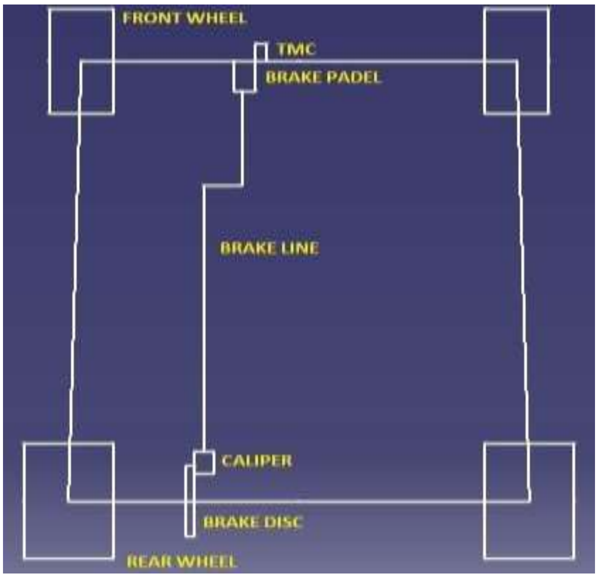
Dry Boiling Point: 2300C

- Wet boiling point : 1550C
- Low Moisture Absorption: Assists in maintaining high temperature performance throughout its service life.
- Anti-corrosion: Provides corrosion protection for metals used in braking systems including cast iron, aluminium, steel, copper, brass etc.
- Elastomer Compatibility: Compatible with rubber seals and hoses.
- Fluid Compatibility: Compatible and miscible with other DOT 4 brake fluids, brake parts material.
- Viscosity limit :1800mm2/s
- Specific gravity : 1.07

Brake System Parameter:

- Brake line pressure: Brake line pressure is the hydraulics force that actuates the braking system when paddle is pushed
- Deaccleration: It is the rate at which a vehicle slows down, simply final velocity-initial velocity with negative sign. This means dropping the speed of vehicle.
- Stopping distance: It is the distance travelled in between the driver realizing the need to brake and actually braking.
- Weight transformation: This include braking and deaccleration no motion of the center of mass relative to the wheels is necessary and so load transfer may be experienced by vehicle with no suspension at all. It is critical concept in understanding vehicle dynamics.
- Rolling radius: It is vertical distance between the centre and the horizontal surface a free rolling tire rotates around a point near the contact patch
- Braking time: It is a time taken by vehicle take to come to a complete stop after the braking
- Paddle ratio: Paddle ratio is the ratio of leverage your brake paddle applies to the master cylinder
- Brake bias: It is describes how much of the braking force is applied to the front and rear wheels respectively normal in brake bias is to the front to ensure a stable straight line deaccleration
- Brake torque: it is the force applied at the wheel to stop the motion of the moving equipment. A brake having retarding torque equal to the full load torque of the motor to which it is applied.
- FOS: It is the ratio of yield stress to the working stress.

III. BRAKE CALCULATIONS AND CONSIDERATIONS LAYOUT OF BRAKE SYSTEM



General Layout of Inboard Braking System

Brake Assumptions:

- Kerb weight = 80 kg
- Gross weight = 140 kg
- Driver weight = 60 kg
- Disc outer diameter = 190 mm
- Disc inner diameter = 60 mm
- C.G. from ground = 4.0 inch = 101.6 mm
- Wheel base=38 inch = 965.2 mm
- Pedal ratio = 4 : 1
- Bias ratio = 40:60
- Average speed = 60 Km/hr
- Maximum acceleration = 1.68 m/s2
- Pedal force = 80 N
- TMC diameter = 19.08 mm
- Caliper piston diameter = 25.4 mm
- Coefficient of friction (μ) = 0.45
- Coefficient of friction between pad and disc =0.6
- Coefficient of friction between road and tire =0.84
- Rolling Radius = 136.09 mm
- Braking time (Stopping time) = 0.840 sec
- Wheel lock : Rear

Weight transfer:

With driver

Weight in rear = 140 * 0.6

= 84 kg

Weight in front = 140*0.4

= 56 kg

Without driver

Weight in rear = 80 * 0.6

= 48 kg

Weight in front = 80 * 0.4

= 32 kg

Dynamic weight Transfer = (a* h *overall weight of vehicle) / (g * wb)

= (19.83*140 * (140*9.81)) / (9.81 *965.2)

= 402.68 N

Dynamic weight in front = Weight in front + Dynamic weight Transfer

= (56 *9.81) + 402.68

= 952.04 N

Dynamic weight in rear = Weight in rear - Dynamic weight Transfer

= (84 * 9.81) – 402.68

= 421.36 N

Brake force:

Fbp= Pedal force * Pedal ratio

= 80 * 4

Fbp= 320 N

Pressure in master cylinder:

Pmc= Fbp / Amc

Amc= π / 4(d2)

= π / 4(19.082)

= 285.92 mm2*

Pmc = 1.11 m/s2

Pressure in brake line and caliper is same,

Pmc= Pcal= 1.11m/s2

Friction force on rotor:

Friction= P * Ac*1 *μ*

Ac= Area of disc

= π / 4(D-d)2

= π / 4(190 -60)2

= (84 * 9.81) – 402.68

= 421.36 N

Ac= 13273.2289 mm2

Friction = 1.11 * 13273.2289 * 0.6 * 0.3142

Friction= 2777.51 N

Brake torque:

TB= Friction* Reff

Reff = Effective radius

Reff = 1/3[(D3-d3)/ (D2-d2)]

Reff = 1/3[(1903-60)/(1902-602)]

Reff = 1/3[(6.64*106)/(32.5*103)]

Reff = 68.133 mm

TB = 2777.5 * 68.10*10-3

TB = 189.24N.m

Clamping force on caliper or force on caliper:

Fcal = Pcal *Acal

Where,

Acal = π/4(d2)

= π/4(25.42)

Acal = 506.70 mm2

Fcal = 1.11 * 506.70

Fcal = 562.437 N

In such way that, the clamping force is generated between two halves of caliper body.

So, Fcal = 562.437*2

Fcal = 1124.874 N

Deceleration:

Friction = mass * acceleration

a = Friction / mass

a = 2777.51 / 140

a = 19.83 m/s2

Stopping distance:-

S = v2/2a

S=(16.662)/ (2*19.83)= 6.92 m ………… (v = 16.66 m/s)

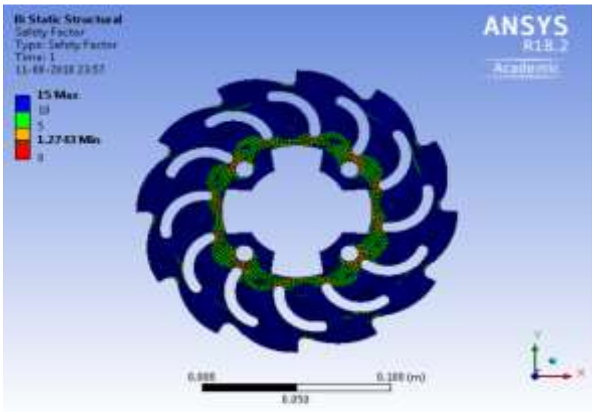
Stopping time:

t = v/a

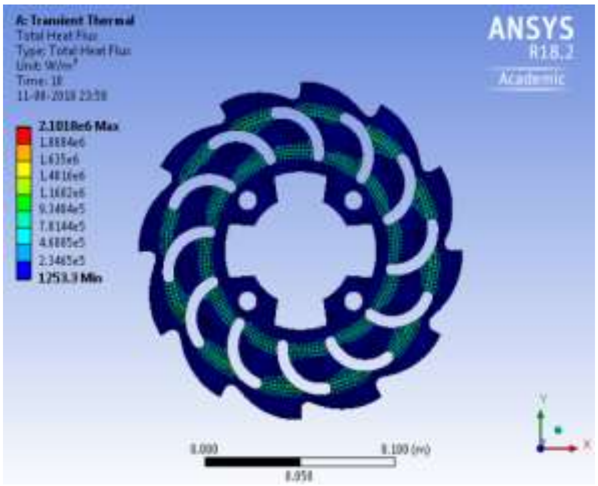
= 16.66/19.83

t = 0.840 sec

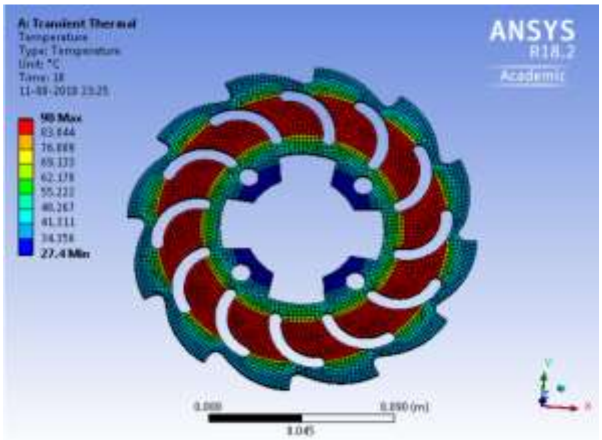
IV. CAE OF BRAKE DISC



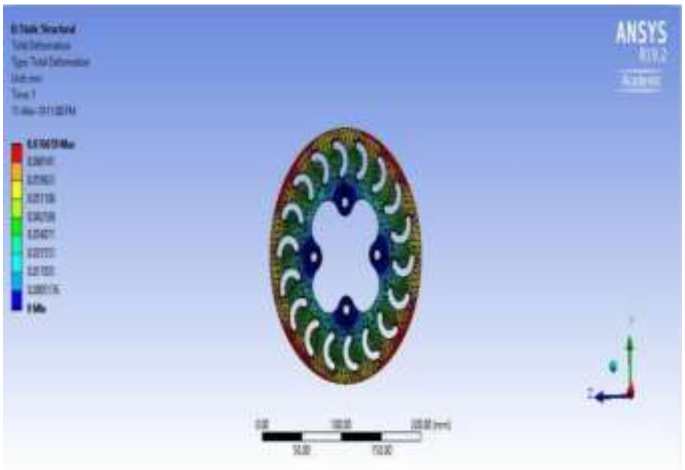
Heat Flux: 1253 W/m2



F.O.S= 1.25



Temperature: 90^0 C



Total Deformation =0.0766 Max

FORMULAS

- Coeff. of friction between road and tire: μ=V/dt*g
- Weight transfer: 140*0.6, 140*0.4 (as per rear and front)
- Brake Torque: Fr*Reff
- Deaccleration: BM/mass
- Stopping Distance: V2/2A

V. CONCLUSION

By using this paper, the readers are able to understand the inboard braking systems, also as we mentioned basic definitions and details calculations which are important while designing the brake are useful to analyze the terminology of brakes. The testing of brake disc is also provided to get better idea for thermal analysis and Factor of Safety.

VI. REFERENCES

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