Design And Analysis of Disk Brakes For Go-Kart

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Abstract- *The brakes are very important part of a vehicle as they provide means to stop the vehicle. As in GO-kart, brakes have to undergo through continuous use, many issues including their heating characteristics when it comes to their development, including contact region properties, material choice, development of hot spots, associated physical geometry, and deformations. The main aim of this study is to analyze the thermal and mechanical behavior of the brake disc during the braking phase. The coupled thermal-structural analysis is used to determine the deformation and the stresses established in the disc to enhance its performance.*

Keywords- Brake calliper, Master cylinder, Disc brakes, Brake force, Heat flux

I. INTRODUCTION

The safe and reliable use of any vehicle necessitates the continuous adjustment of its speed and distance. A brake is a mechanical device which inhibits motion, slowing or stopping a moving object or preventing its motion. Generally mechanical brakes are used widely because of their simplicity. Mechanical braking systems include drum brakes, disc brakes, hydraulic brakes etc. The brakes used in GO-kart are Hydraulic disk brakes. When the brake pedal is pressed, due to hydraulic pressure, a piston pushes the brake pad against the brake disc and it allows to slow down. A brake disc is usually made of cast iron, but in some cases it is made of composites such as reinforced carbon-carbon or ceramic-matrix composites.

II. BASIC PRINCIPLE OF DISK BRAKES

A brake is a device by means of which artificial frictional resistance is applied to moving machine member, in order to stop the motion of a machine. In this process, the brakes absorb kinetic energy of the moving member. The energy absorbed by brakes is dissipated in the form of heat. This heat is dissipated in to the surrounding atmosphere. A disc brake is a type of brake that uses hydraulic pressure to squeeze pairs of pads against a disc in order to create friction, to reduce speed or stop the kart.

Why we select the disc brakes:

1. Heating of the Brake rotor increases its thickness thereby causing no loss in brake fluid volume.
2. Better stability than Drum Brake.
3. Increase in temperature does not affect the disc pads.
4. The braking design is simple.
5. Maintenance and repairs of disc brakes is easy.
6. Disk brakes weigh less than drum brakes.
7. The major advantage of the disc brake is its ability to operate with little fade at high temperatures of up to 1073 to 1173 K, while drum brakes are highly temperature sensitive. A maximum temperature of 673 to 700 K should not be exceeded.
8. Water and dirt resistant.
9. Better cooling, Friction surfaces are directly exposed to air in disc brake while in drum the friction surfaces are not directly exposed to air.

Total frictional area of disc brakes is very less as compared with the conventional drum type brakes, the approximate ratio being 1:4. This means that in disc brakes, the pressure intensity must be considerably greater than in the drum type. This implies that frequent relining would be necessary, due to increased rate of wear.

III. CONSTRUCTION OF DISK BRAKES

The most common arrangement of hydraulic disk brakes consist of following components:-

1. Brake disks
2. Brake pedal
3. A master cylinder assembly containing a piston assembly and a reservoir
4. Hydraulic fluid lines

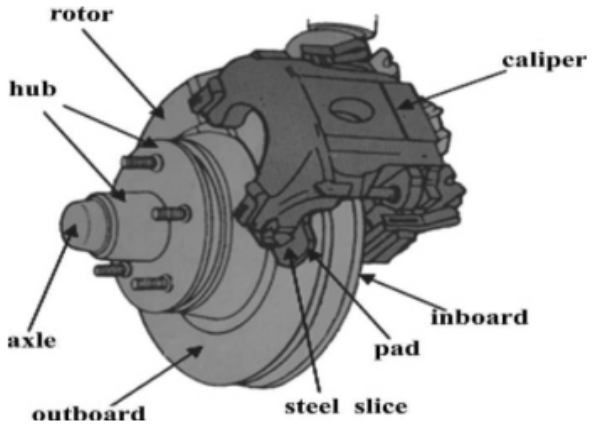

Fig.1 Disk brake assembly [1]
(D.P. Bhaskar, et.al 2014)

Brake calliper assembly consists of one or two hollow aluminium or chrome-plated steel pistons and a set of thermally conductive brake pads. Master cylinder is used to generate the required hydraulic pressure on brake pads. Reservoir carries the brake fluid (here DOT-3 oil is used). Hydraulic lines carry the pressurised fluid to the calliper pad assembly.

IV. WORKING

When a brake lever or pedal is pressed, the push rod which is connected to lever or pedal and master cylinder piston pushes the master cylinder piston. This movement allows the master cylinder piston to slide and push the return spring inside the bore of master cylinder, which generates pressure in reservoir tank. At this moment a primary seal allows the brake fluid of reservoir tank to flow over it into the brake hosepipes. A secondary seal ensures that the brake fluid does not go other side. Then the fluid enters in to cylinder bore of calliper assembly via brake hosepipes and pushes the calliper piston or pistons. At this time the piston ring moves in rolling shape with piston. Then the calliper piston pushes brake pad. This movement causes brake pads to stick with brake disc which creates friction and stops the brake disc/rotor to rotate. This way disk brake system stops or slows down the vehicle. [2]

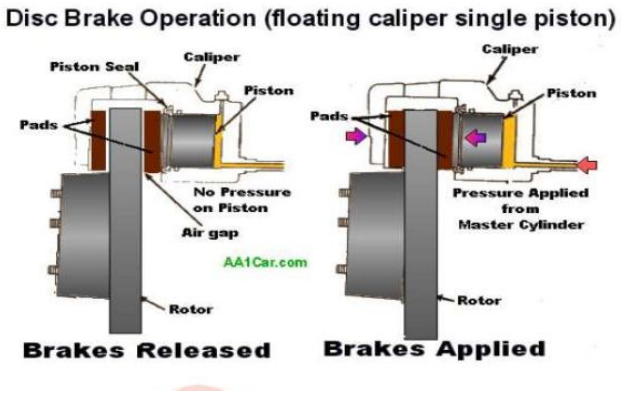

Fig.2 Working of disk brakes[2]
(Prof. Mit Patel, et.al 2016)

When the brake lever or pedal is released the piston ring pushes the calliper piston back to cylinder bore of calliper till both, calliper piston and piston ring come into their original shape. At this time retraction spring pushes the brake pads to their original position. The return spring in master cylinder assembly pushes the master cylinder piston back into its original position and allows the fluid to flow back to reservoir via hosepipe and master cylinder bore. [2]

V. PROPOSED DESIGN AND ANALYSIS

The braking system uses a rear braking circuit. The breaking system was designed by determining parameters necessary to produce a given deceleration, and comparing to known braking system would produce. One master cylinder having bore diameter of 14mm is used. One floating dual piston calliper on the rear inboard is used. The brake callipers are connected to the master cylinder with the synthetic rubber hoses which insures that there is no leakage of the brake fluid.
Pedal ratio = 1:6

Material for rotor = SS304

Important definitions:-

- Actuating force-

The actuating force, is the force that is applied to the actuation device.

- Total braking force-

The total braking force, is the sum total of braking forces at each of the wheels that are produced by the effect of the braking system and which oppose the vehicle's motion or its tendency to move.

- Braking torque-

The braking torque is the product of the frictional forces generated in the brake by the application forces and the distance of the point of action of those forces from the axis of rotation of the wheel.

- Braking-force distribution-

The braking-force distribution indicates in terms of percentage share how the total braking force, is distributed between the front and rear wheels e.g. front wheels 60%,rear wheels 40%.

Required Calculations

- Where Weight=170 kg,

  pedal ratio=6,
  μ=0.4
- Gross weight= (g * weight of vehicle)

  = 9.81*170
  = 1667.2 N
- Brake line pressure(P)= force on brakes /

  area of mastercylinder *= 150/153.93*
  = 0.97 N/mm
- Clamping force = Brake line pressure* area of calliper

  *Piston*2*
  *=0.97*57255*2*
  =1110.747 N
- Rotating force = CF * no of calliper piston*coefficient Of friction

  *=1110.747*2*0.4*
  =888.59 N 5)
- Static weight on front axle = (0.45*vehicle weight)

  *= 0.45*170*
  =76.5 kg
- Static weight on rear axle = (0.55*vehicle weight)

  *= 0.55*170*
  =93.5 kg
- Braking torque = (RF*effective radius)

  = 888.59[(180-30)/2]*
  *=888.59*75*
  = 66644.25 N-mm
- Braking force = (BT/tyre radius)* coefficient of friction

  between tyre and surface

*= (66.64/139.7)*0.8*
= 381.61 N

- Deceleration (a)=BF/m

  =381.61/17.32
  =22.03 m/s2
- Stopping distance (s)

  $v^2-u^2=2as$
  *0-16.662 =2 *22.03*s*
  S=6.29 m.

Specifications:-

- Stopping time =0.37 sec
- Estimated speed =60 km/hr
- Pedal effort =150N
- Force acting on master cylinder =900N
- Diameter of master cylinder =14mm
- Area of master cylinder =153.93 mm^2
- Pressure acting on master cylinder =95958n/mm^2
- Area of piston in callipers =572.55 mm^2
- Pressure acting on calliper = pressure in calliper
- Force acting on calliper =p*a =54094*106 N
- Coefficient of friction between pad and rotor =0.4
- Friction force between disc and pad =44029 N
- Effective radius of rear disc =70 mm =0.07 m
- Bore diameter of master cylinder =14 mm
- Diameter of calliper piston =27 mm
- No of calliper piston = 2
- Disc diameter =170 mm (outer diameter)
- Disc thickness = 4mm.

Analysis:-

1. Heat dissipation of disc

Heat is generated in disc due to the friction between calliper pistons.

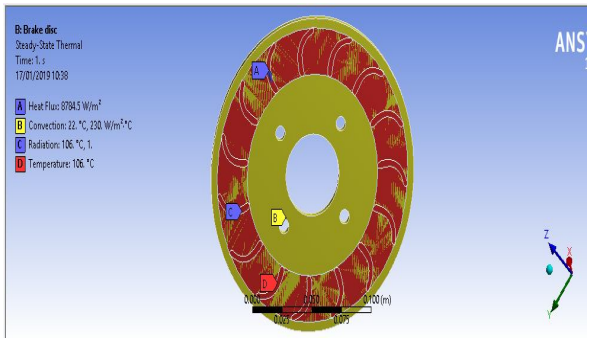

Fig.3 Heat Flux

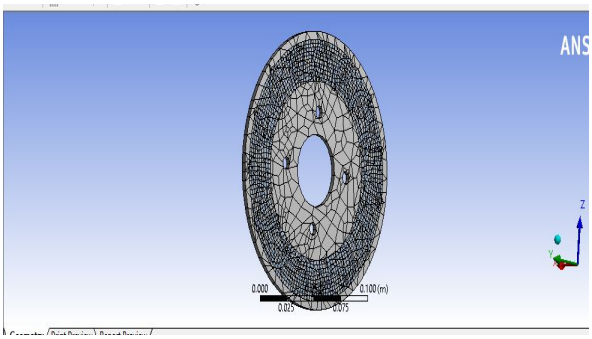

Fig. 4 Meshing

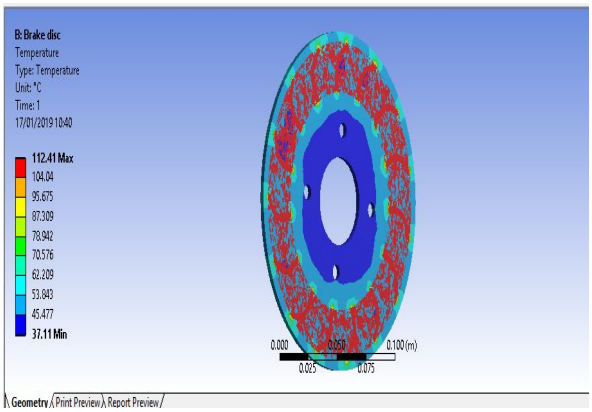

Fig. 5 Thermal anlysis of disk

VI. CONCLUSION FROM ANALYSIS

From the thermal analysis of brake disk following result is obtained:-

Total heat flux =8784.52 w/m^2

Temp. = 112.41^{0}c

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