Design and Analysis of a Go-Kart Braking System

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Abstract— In today's world when people go out to purchase a bike or a car, the first concern that arises in their mind is about the top speed of the vehicle. Many people don't consider the parameters required to maintain this speed. Karting is commonly perceived as the stepping stone of a formula one car, as we rise upwards from one car to another the speed and G's increase from stage to stage. French philosopher Voltaire has quoted that 'With great power comes great responsibility, on the same grounds, 'With Superior Speed comes the need of an efficient and effective braking system.' Most international Go-Karts operate at a speed of 100-120 mph (180 km/hr.), for handling this speed one needs a very streamlined braking system. Effective braking system is the key to control any vehicle at high speeds. In this paper we are designing and analyzing a Braking system for national level inter-college Go-Kart competition. All the calculations done in this paper are pertaining to our kart. The Analysis of the disc brake is done in Ansys 18.0 Workbench.

Key words: Go-Kart, Braking System, Efficient, Streamlined, Ansys 18.0, Superior Speed

I. INTRODUCTION

A brake is a device which uses frictional resistance to the moving member in order to retard the motion. They are applied on the rotating component which creates conversion of Kinetic energy to heat due to the friction factor. Hydraulic Disc brakes have been used in the Go-kart braking system as they are more reliable and dissipate more heat compared to other brakes. Moreover disc brakes give driver stability while applying the brakes at high speed. As the brake pedal is engaged, the brake fluid flows to the brake pads which are pushed against the brake disc in the wheel caliper assembly. The Kinetic energy is converted into heat form which is thrown away through the vents on the rotor hence reducing the speed of the vehicle. Disc brakes have proven to be effective than other brake systems.

The Disc is made using SS304 which is fitted to the caliper assembly. The wheel hub has the caliper assembly which is c stops axle rotation. The Go-kart uses ventilated disc to improve the heat dissipation process connected to the axle. Hence the disc can be stopped which

We are using Rear Braking system with Disc of Diameter 170 mm (custom made) which is operated by Double piston Caliper hydraulic system. We didn't go for both front and rear braking as; one rotor disc is sufficient to handle the full braking of the vehicle. DOT- 3 Brake fluid is used as it is economical, easily available and compatible with the vehicle.

II. DISC MATERIAL

Out of many options to choose from Mild steel and other metals, we chose SS304 as the material for our brake disc.SS304 grade is the most used stainless steel for brake rotor manufacturing. Once the heating process is done on SS304, the material becomes very strong and rigid to withstand thermal and dynamic loads. This grade of SS has better thermal dissipation and is corrosion resistance

A. Selection of Fluid

The brake fluid is the lineage of the vehicle's braking system. It keeps the braking components lubricated and prevents corrosion so that they respond instantly with good efficiency when you press the brake pedal.

DOT 3 is the most common and popular brake fluid type. Although DOT 4 is also considered good due to its compatibility, DOT 3 is durable and economical option.

Three factors namely- boiling point, chemical structure, boiling capacity play an important role in effective braking. The reasons for choosing DOT 3 for our kart are-

1) Boiling Point

This shows the tendency to absorb water. Though DOT3 has low boiling point which is high tendency to absorb water, racing takes place on track which is dry environment. DOT 4 should be used only when needed. In this case DOT 3 will be suffice.

2) Chemical Structure

DOT 3 has combination of ether and poly-alkylene glycol which is a good bond for karting related applications.

3) Boiling Capacity

DOT 3 is good for wet environments too. Hence using DOT 3 is an advantageous point.

III. BRAKE SYSTEM PARAMETERS

Brake Type	Hydraulic Disc Brake
Brake Material	SS 304
Disc Diameter	170 mm
Master Cylinder Diameter	10
Caliper Piston Diameter	25.4mm
Disc Thickness	4 mm
Pedal Force Applied	189.39 N
Pedal Ratio	3:1

Table 1: Brake System Parameters

IV. CALCULATIONS

- Gross Weight Of kart = 160kg
  =160*9.81
  = 1569.6 N
- Pedal Force =19kg
  =19*9.81
  = 186.39 N
- Brake Line Pressure
  P = (Pedal Ratio*Force by pedal) ÷ Area of M/C
  = (3*186.39) ÷ (π÷4*(0.01)^2)
  = 9.065 MPa
- Clamping Force
  C.F=P * Area of Caliper Piston * No of Caliper
  =9.065*10^6*(π÷4*(0.0254)^2)*2
  =9186.6 N

- Rotating Force
  R.F=C.F*μ*No of calipers
  =9186.6*0.3*2
  =5511.96 N
- Braking Torque
  B.T = RF*Disc Radius
  = (5511.96)*(85*10^-3)
  =468.51 NM
- Braking Force
  BF = BT ÷ (Tire radius*μ)
  = (468.51) ÷ (0.1397) *0.8
  =2682.94 N
- Deceleration
  = Braking Force/Mass of vehicle
  = (2682.94/160)
  = 16.76 m/s
- Stopping Distance
  = V^2-U^2=2as
  = (12.5)^2-0=(2*16.76*s)
  = 4.66 m

A. Justification

Here initial speed is considered as 45 km/hr. which is equal to 12.5 m/s.

- Stopping Time
  = (v-u)÷a=t
  = (12.5-0)/16.76=t
  = 0.75 Sec
- Actual Weight Transferred
  Weight Transferred=160*1*99.9÷(1030)
  Weight Transferred =152.23 N
- Dynamic Front Weight
  =Weight on rear tire-Weight transferred
  =789.53 N
- Dynamic Weight on 1 front stub axle
  =780÷2
  =390 N
- Frictional Force
  At each front wheel
  = 0.4*Dynamic Weight on 1 Front Stub Axle
  = 0.4*390
  = 156 N
- At each Rear wheel
  = 0.6*Dynamic weight on Rear Stub Axle÷(2)
  = 236.85MPa
- Energy
  ϒ (Weight distribution on each side) = 0.5
  % of Kinetic Energy that Disc would absorb(K)=90%
  ϒ=0.5
  K=0.9
- Total Kinetic Energy
  T.K.E = (1÷2)(mv^2)*k* ϒ
  =0.5*160*$(12.5)^2$*0.9*0.5
  T.K.E = 5625 J
- Total Braking Power(Pb)
  =Kinetic Energy/ Stopping time
  =5625/0.75=7500 W
- Total Heat Flux =PB/A
  =7500/0.0267
  280898.8W/M^2

V. ANALYSIS

A. Meshing

Meshing is done with the element size of 5mm the, the complete meshing was adaptive. Following data has been found after meshing the chassis.

- No. of nodes= 26910
- No of elements= 9908

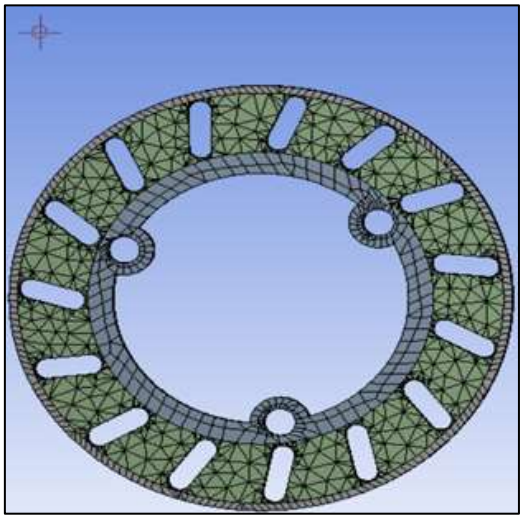

FIG. 1: Meshing of Brake Disc

B. Boundary Conditions

- Radiation = 22 deg C
- Convection =22 deg C
- Heat flux = 2.3*10^-2 W/mm2

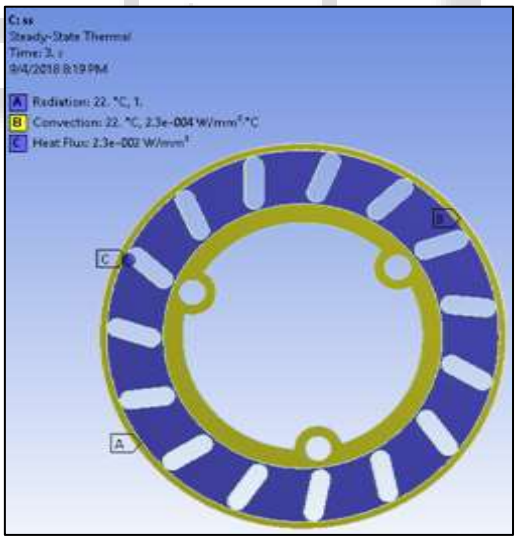

Fig. 2: Boundary Conditions of Brake Disc

C. Heat Flux

After the analysis was done the total heat flux produced in the brake disc was found to be .05W/mm2

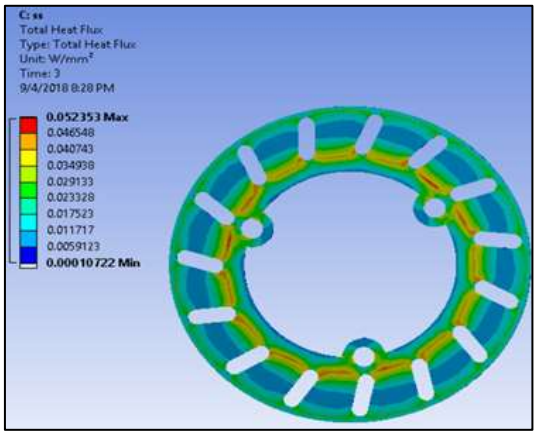

Fig. 3: Heat Flux of Brake Disc

D. Temperature

Post analysis the temperature produced by the braking on the brake disc was observed to be 95 deg C.

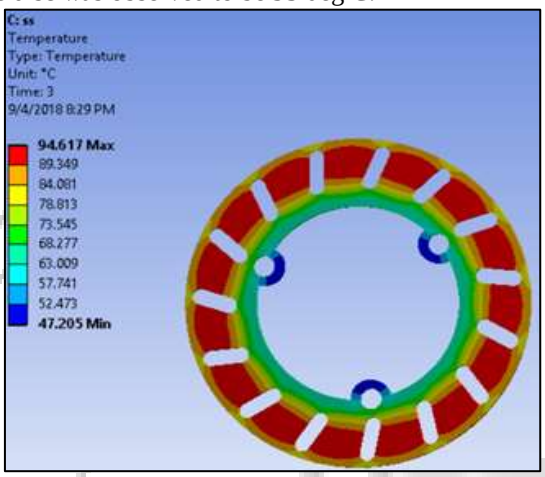

Fig. 4: Temperature of Brake Disc

E. Static Analysis

1) Boundary Condition

Brake disc calculation is given in the design report, as per the theoretical values from the design report, the boundary condition

- Force by the brake
- And the torque
- And the brake is fixed in the its holes

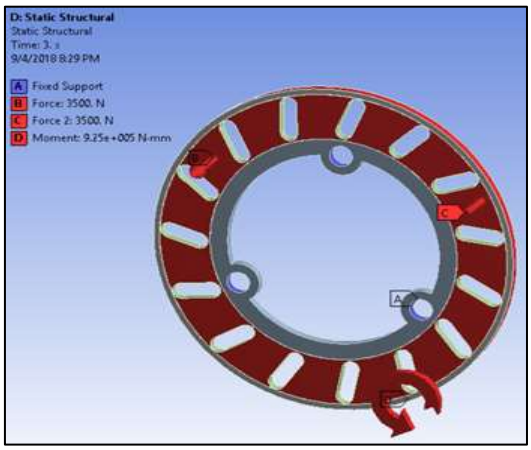

Fig. 5: Boundary Conditions of Brake Disc

F. Deformation

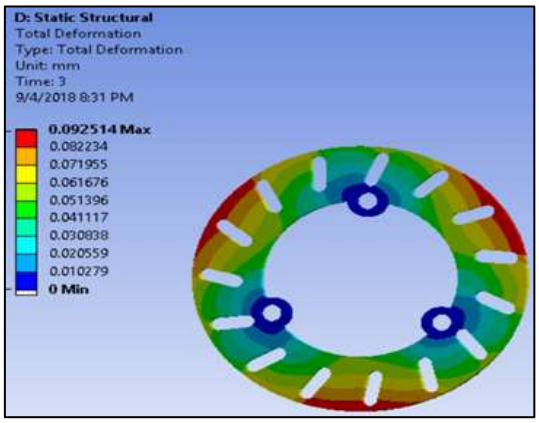

Fig. 6: Deformation of Brake Disc

After the analysis, the deformation of the brake was found to be 0.09mm

G. Stresses

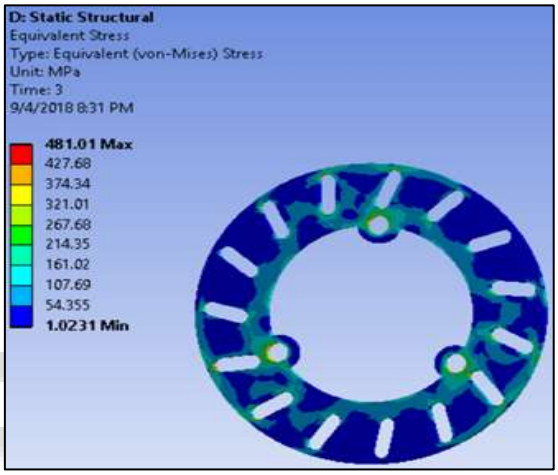

Fig. 7: Stresses in Brake Disc

After the analysis the stresses were 482 MPA.

VI. CONCLUSION

The objective was to design an effective, safe, durable braking system. The calculations have shown the required parameters for designing the system. The layout is later analyzed and tested for racing conditions. The brakes have proven to be effective and hence, the kart has cleared the braking test in competition. The final values of our braking test are as follows-

Pedal Force	186.39 N
Brake Line Pressure	9.065 Mpa
Clamping Force	9186.6 N
Rotating Force	5511.96 N
Braking Torque	468.51 Nm
Braking Force	2682.94 N
Deceleration	16.76 m/s^2
Stopping Distance	4.66 m
Stopping Time	0.75 sec

Table 2: Calculated Values of Brake

These results have shown the success of analysis and designing a good braking system.

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