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Design and thermal analysis of a two wheeler disc plate at different speeds using ANSYS software.

[1]Ayush Gupta, [2] MayankUpadhyay, [3]Prof. Tapnokumarhotta

[1,2,3] *Vellore Institute of Technology India*

ABSTRACT:- *There is lot of up gradation in the automobile technology these days. Competition on the speed of vehicles is the prime factor in deciding the best vehicle at the same time keeping the safety norms in our mind. Apart of having best vehicle dynamics, great suspension frameworks, best engine specifications, there is one most basic system in the vehicle which is braking mechanisms. Main problem dealing with disc brakes is the heat generated due to the braking forces and friction forces thus design and material used which are best suited to dissipate most of the heat thus increasing the life span of the disc brakes.*

This paper deals with design and thermal analysis through ANSYS workbench analysis of a two wheeler disc plate comparing the final temperature and total heat flux dissipated. The design has been taken from real world. Dimensions of Bajaj discover has been taken and edited in solid works. Materials like aluminium alloy, cast iron or stainless steel has been selected for analysis to compare to compare with different designs at two different speeds of the vehicle. After all the analysis the data has been tabulated and a result is found out to concluding the best material with a design also comparing the percentage increase in the final temperature and total heat flux dissipated.

Key words: *ANSYS Software, Thermal Analysis, Brake Disc, Cast Iron, Aluminium alloy*

INTRODUCTION

Apart of having best vehicle dynamics, great suspension frameworks, best engine specifications, there is one most basic system in the vehicle which is braking mechanisms. Main problem dealing with disc brakes is the heat generated due to the braking forces and friction forces thus design and material used which are best suited to dissipate most of the heat thus increasing the life span of the disc brakes.

The disk brake is basically a kind of wheel brake that helps in slowing down the rotation of the wheel using the friction, this friction is generated by pressing brake pads against the brake disk which involve the set of callipers. The brake disk of the vehicle has a cast iron, ceramic composites including carbon, aluminium, Kevlar as its main parts for the slowing down the vehicle. A friction material which is being produced in the form of brake pads is forced mechanically, hydraulically, pneumatically and electromagnetically against the both sides of the disk thereby causing heat generation. This friction makes the disc and join wheel to slow or to stop the vehicle.

The study of brake analysis is very significant due to safety issues. The brakes should apply such that a vehicles would not skid and would take minimum time to stop.

Also vehicle produces huge amount of heat. Braking performance is largely affected by the temperature rise in the braking components. High temperature may give thermal cracks, brake fade, wear and reduction in coefficient of friction. Thus thermal analysis is done to model the situation of real life and alter the design specification.

During the course of braking, thermal energy generated from the translation of kinetic and potential energies of a moving vehicle due to friction in the brakes. This heat transfer takes place by conduction, convection and radiation at all the surfaces. To have appropriateoutput flux of the disc and the pads by convection and radiation study of the heat transferprocess between disc, pad and the air medium is essential. Then it is very much important to analyse the thermal performance of the disc brake system to predict the rise in temperature during braking. Convective heat transfer model has been made to analyse the cooling performance. Brake discs are provided with cuts and grooves to increase the surface area coming in contact with air and improve the heat transfer from disc.

The findings of this paper gives a useful design and material which will help to improve the heat distribution of the disc thus improving the efficiency of the brakes.

OBJECTIVE

- Calculate the total heat generated through a finite braking distance.
- Design three disc brakes of a Bajaj discover motorcycle.
- Analysing temperature distribution andheat flux.
- Material selection for best temperature distribution, most heat dissipation and least weight.
- Comparison of heat dissipated at 80 km/h and 60km/h

ASSUMPTIONS:

- The analysis is done taking the distribution of the braking torque between the front wheel and rear wheel is 25:75

- Brakes is applied on all the front wheel only.
- Only ambient air-cooling is taken in to account and no forced convection is taken.
- The disc brake model used is of homogenous material.
- The thermal conductivity of the material used for the analysis is constant throughout.
- Heat flux on each front wheel is applied on one side of the disc only.

STEPS INVOLVED

- Modelling of part model in the Solid works.
- State Thermal analysis in ANSYS
- Geometrical analysis and meshing of the part.
- Applying boundary condition and initial condition at T = 22 ^{0}C and analysis time
- Apply Heat flux, Convection for all the surface faces at 230 W/mm^2 and Radiation for all the surfaces.
- Applying material conditions and checking maximum temperature also maximum heat flux.

PROBLEM DOMAIN

For the braking performance calculations
FOLLOWING IS THE DATA OF BAJAJ DISCOVER 150 CC REQUIRED –

1. Mass of the vehicle + driver = 190 kg (120+70 kg)
2. Initial velocity (u) = 22.22 m/s (80 km/h) and 13.9 m/s (50 km/h)
3. Final speed (v) = 0 m/s
4. Brake rotor diameter = 200 mm
5. Coefficient of friction for dry road µ = 0.50
6. Maximum pressure = 1MPa (106 Pa)
7. Brake pad area (standard) = 2000 mm^2
8. (staic front axle load / total motor cycle load)(γ)=0.25
9. Percentage of kinetic energy that disc absorbs (80%) k=0.80

CALCULATIONS

1. Tangential force –

Normal force (pad and brake rotor) inner
= FRIT
= µ.FRI
= (0.5)(Max pressure x area)
= $(0.5)(1\times10^6$ N/m2) $(2000\times10^{-6}m^2$
= 500 N
Normal force (pad and brake rotor) outer face = 500 N

Total force (FT) = 1000 N

Brake Torque -

TB = FT.R
= $(1000)(100 \text{ X } 10^{-3})$
= 100 N.m

Time to stop the vehicle and total heat generated

FOR 80 km/h

Work done = (FT x Brake Distance)
= change in kinetic energy
1000.x = (mv^2)/2
x = (190x432)/2x1000
x = 41 m
$v^2 = u^2 - 2as$ and
v = u + (at)
22.2= 0 + (6 x t)
t = 3.8 secs
T.K.E = mv^2/2 = (190*492)/2 = 46820 J
K.E = (T.K.E)*(.80)*(.25) = 9364 J
Area of Disc (approximate including the holes) = 23000 mm^2
Heat Flux
= Heat Generated /Second /area
= 9364 /3.8 /0.023
= 107139 W/m^2

Time to stop the vehicle and total heat generated

FOR 50km/h

Work done = (FT x Brake Distance)

= change in kinetic energy

$1000.x = (mv^2)/2$

$x = (190x193.21)/2x1000$

x = 18.4 m

$v^2 = u^2 – 2as$ and

v = u + (at)

13.9= 0 + (5.2 x t)

t = 2.67secs

T.K.E = $mv^2/2$ = (190*193)/2 = 18335 J

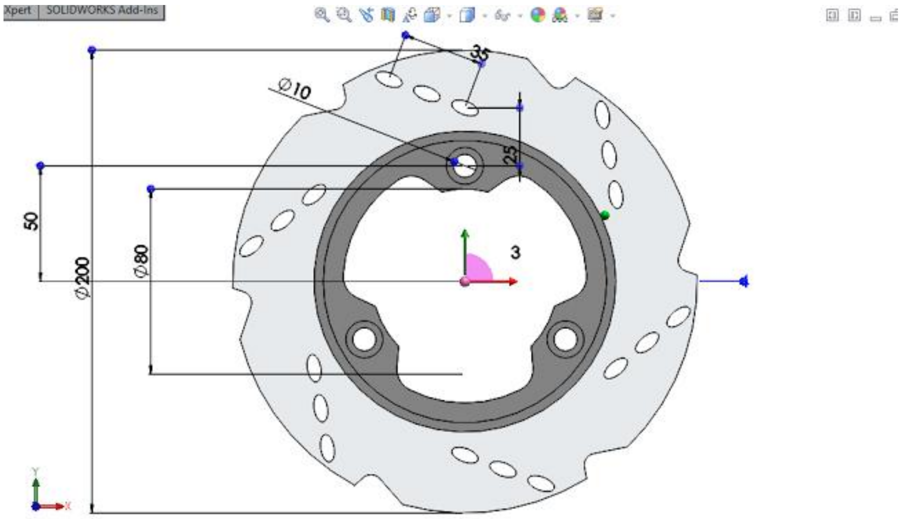
K.E = (T.K.E)*(.80)*(.25) = 3667 J

Area of Disc (calculated from ANSYS) = 23000 mm 2

Heat Flux = Heat Generated /Second /area = 9364 /2.67 /0.023

= 59713W/m^2

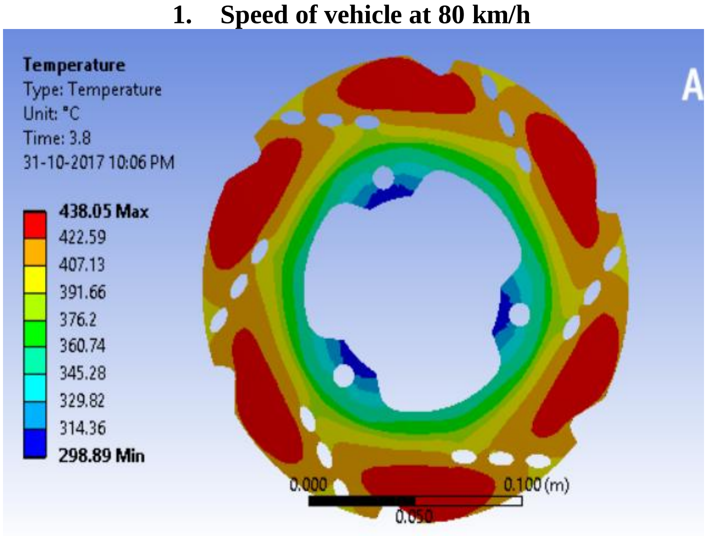
SOLID MODELLIG OF DISC – Design

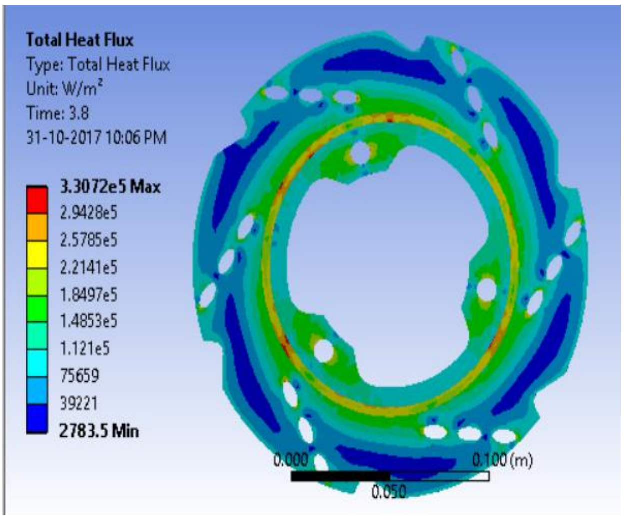


The design is analysed on three different material i.e.aluminium alloy, cast iron or stainless steel for different input flux 107139 W/$m^2$and 107139 W/m^2

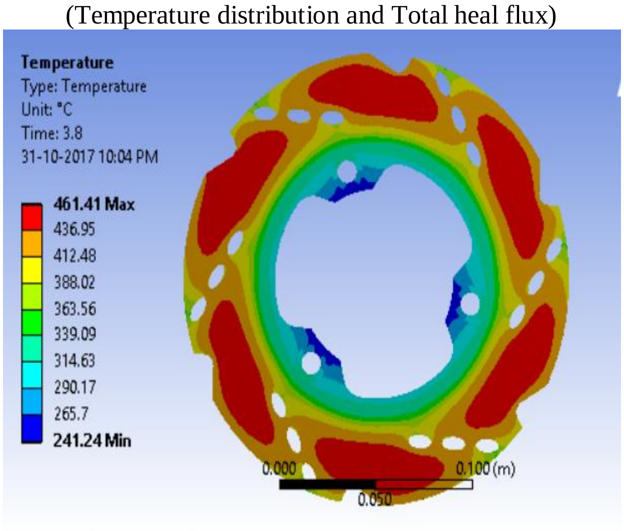
THERMAL ANALYSIS RESULTS

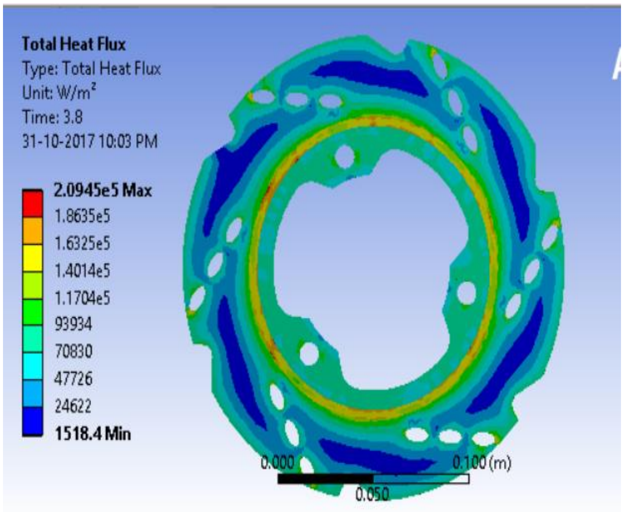
1. Speed of vehicle at 80 km/h



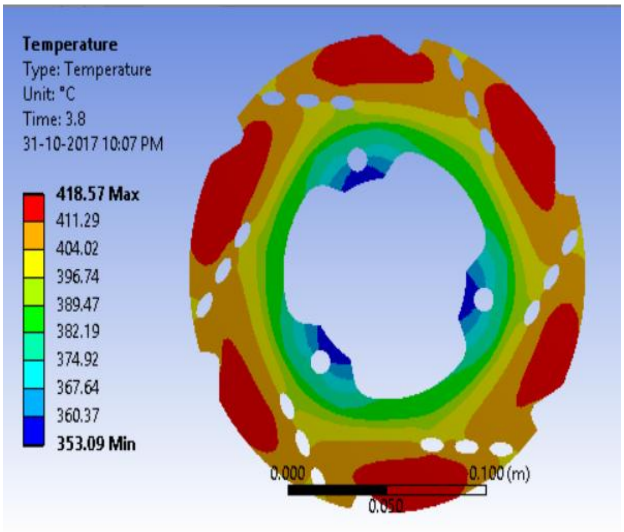


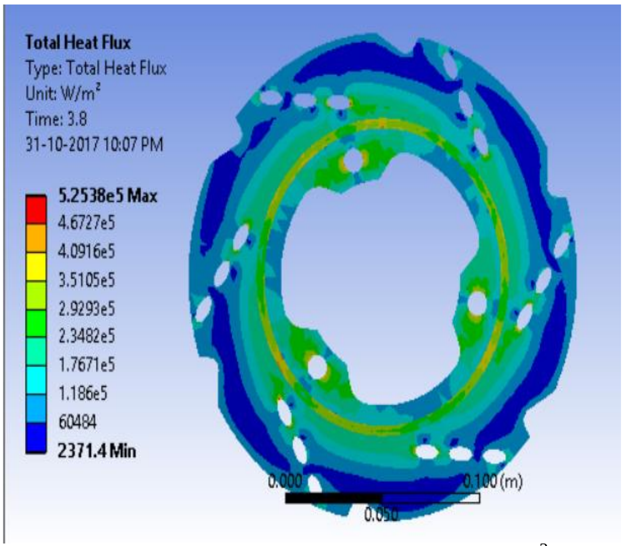
Grey cast iron – Input flux (107319 W/m^2)
(Temperature distribution and Total heal flux)





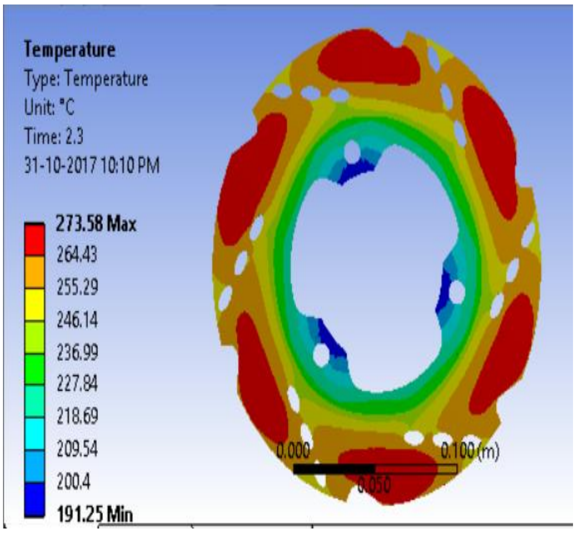
Stainless steel – Input flux (107319 W/m^2)
(Temperature distribution and Total heal flux)

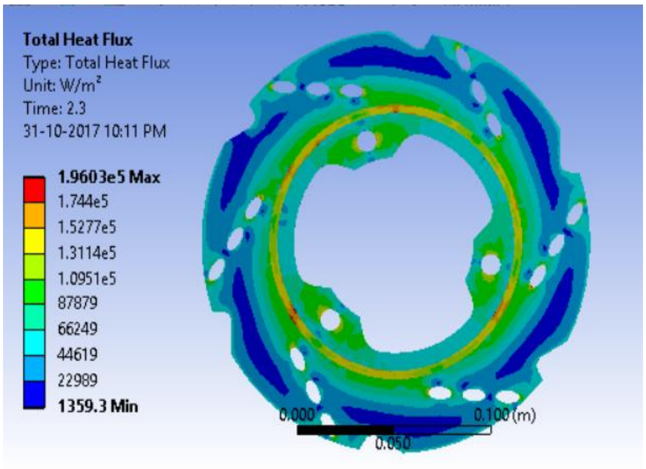




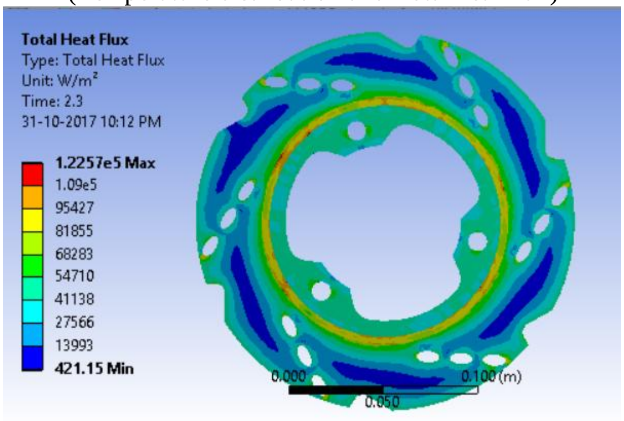
Aluminium Alloy – Input flux (107319 W/m^2)
(Temperature distribution and Total heal flux)

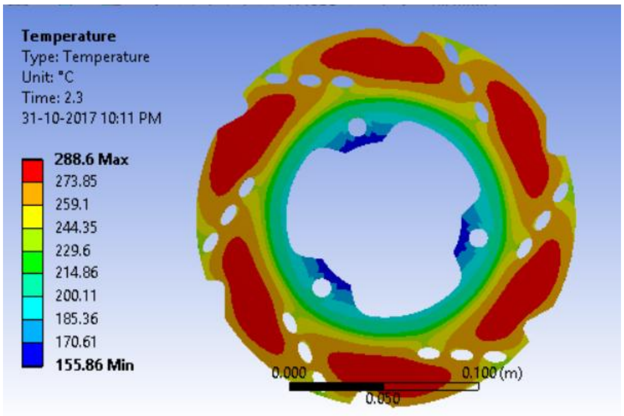
2. Speed of vehicle at 50 km/h



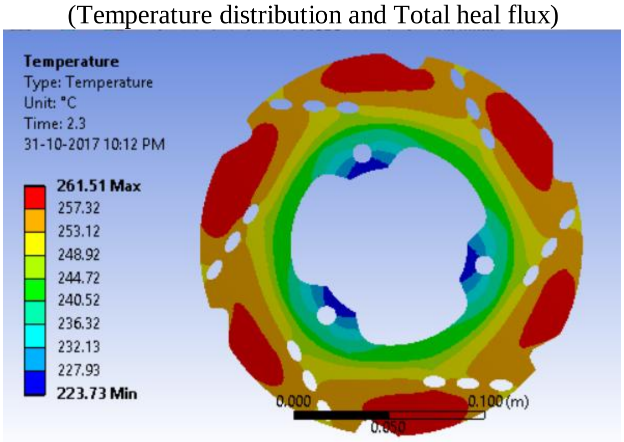


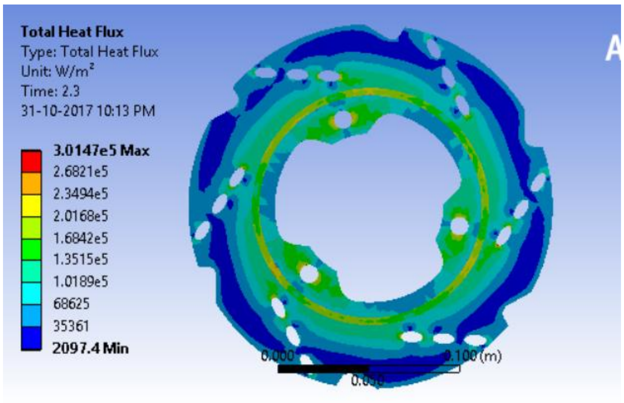
Grey cast iron – Input flux (59713 W/m^2)
(Temperature distribution and Total heal flux)





Stainless steel – Input flux (59713 W/m^2)
(Temperature distribution and Total heal flux)





Aluminium Alloy – Input flux (59713 W/m^2)
(Temperature distribution and Total heal flux)

FINAL RESULTS -

The analysis of material for better utilization of the material to increase the fatigue strength of the disc thus increasing the braking efficiency allowing longer operation of the vehicle at the optimum speed. The comparison is given below-

Material used and initial speed	Mass(kg)	Highest temperature (℃)	TOTAL HEAT FLUX (W/M2)
Grey Cast Iron (80 km/h)	0.62	438	330720
Stainless Steel (80 km/h)	0.671	461	209450
Aluminium Alloy (80 km/h)	0.235	418	525200
Grey Cast Iron (50 km/h)	0.62	274	196030
Stainless Steel (50 km/h)	0.671	289	122570
Aluminium Alloy (50 km/h)	0.235	262	301470

From the above results clearly Aluminium alloy plays well giving higher heat flux thus highest heat dissipation against stainless steel and grey cast iron thus presenting better temperature distribution.

CONCLUSION

1. By this methodology we can calculate total heat generated though the above formulations in the disc brake.
2. Disc plate design should be carefully selected which is having the least weight and more holes of various shapes so as to achieve best results of temperature distribution.
3. The results we got shows Aluminium alloy gives better results than grey cast iron followed by stainless steel giving higher heat flux thus highest heat dissipation.
4. Most of the disc brakes are made of grey cast iron because it is cheaper in cost and it is easily machinable and results are just close to that of Aluminium alloy
5. At 80 km/h it shows approximately 70% increase in total flux and 60% increase in highest temperature. Thus optimum speed of a vehicle should be around 50 km/h.
6. Transient heat transfer analysis can be be the scope of this work.

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