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Performance Analysis on Disc Brake of Super Bikes

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***Abstract*:- The disc brake is a device for slowing or stopping the rotation of a wheel. Repetitive braking of the vehicle leads to heat generation during each braking event. Transient Thermal and Structural Analysis of the Rotor Disc of Disk Brake is aimed at evaluating the performance of disc brake rotor of a car under severe braking conditions and there by assist in disc rotor design and analysis. Disc brake model and analysis is done using ANSYS workbench 16. The main purpose of this study is change the structure of the brake disc by providing a hole from top position. The atmospheric air is supplied through the hole, due to this changing the thermal conductivity is decreased and we reduce the high temperature formation.**

INTRODUCTION:

The disc brake is a wheel brake which slows rotation of the wheel by the friction caused by pushing brake pads against a brake disc with a set of calipers. This is connected to the wheel and/or the axle. To stop the wheel, friction material in the form of brake pads, mounted on a device called a brake caliper, is forced mechanically, hydraulically, pneumatically or electromagnetically against both sides of the disc. Friction causes the disc and attached wheel to slow or stop. Brakes convert motion to heat, and if the brakes get too hot, they become less effective, a phenomenon known as brake fade. Most drum brake designs have at least one leading shoe, which gives a servo-effect. Drums are also prone to "bell mouthing", and trap worn lining material within the assembly, both causes of various braking problems.

BRAKE DISC:

The brake disc is the component of a disc brake against which the brake pads are applied. The weight and power of the vehicle determines the need for ventilated discs.[13]The "ventilated" disc design helps to dissipate the generated heat and commonly used on the more-heavily-loaded front discs.

BRAKE FAILURE CAUSES:

- Before you can understand brake failure, you must understand how brakes work.
- The brake system is rather like this children's song verse, "The head bone's connected to the neck bone, the neck bone's connected to the shoulder bone. In vehicles, the brake pedal is connected to the pistons, and the pistons are connected to the brakes. Most modern cars have disc front brakes and drum rear brakes.
- Functioning brakes stop a vehicle by using friction. In this way, they are unlike the engine, which must always be kept lubricated to run smoothly. In front brakes, friction stops the brake calipers and pads. In rear brakes, friction hits the brake drums and shoes.
- Several factors can interfere with this friction and lead to brake failure:
- Grease or oil on brakes causes brake failure, because it interferes with friction. If oil leaks, it may indicate that an oil seal has failed.

DANGERS OF BRAKE FAILURE:

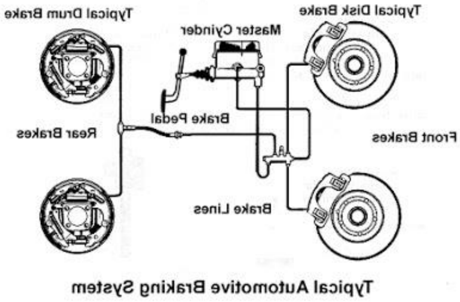
- Brakes function because of a special hydraulic, or liquid-based, system. Brake fluid moves from the pedal through the brake-line system. Because liquids can't be compressed, they move. It is this movement that pushes against the mechanism that stops the vehicle. So when this fluid runs low, brake problems will occur.
- The most apparent danger in brake failure is the possibility of injury or death. As a result, it is important to wear a seat belt and to be certain that guidelines for infant and child car seats are met to ensure safety. Don't forget to be alert to and aware of pedestrians on or near the roadway.
- Another concern is property damage. This includes the vehicle itself but also trees, power lines, highways signs and telephone poles. Damage to private or public property will need to be compensated, which can affect your auto insurance premium.
- Don't let the dangers of brake failure frighten you. Read on to learn what you can do in the event of brake failure.

MANUFACTURING OF BRAKE DISC:

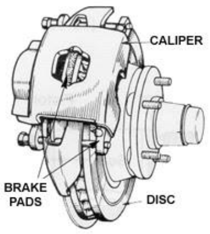
Introduction:

In modern days, the use of metal is vast and there are various methods of manufacturing a product from only use of pure molten metal or from any other state of metal as well. When considering the different methods of manufacturing, most popular methods used in large industries are as follows:

- Metal casting
- Metal cutting
- Metal forming and shaping
- Fabrication and welding



The disc brake system is one important system to look at since it is not only used in automotive industries but also in locomotives and in jumbo jets as well and hence elaborating more on disc brake system, the main components of a disc brake are the Brake disc or Rotor, Brake pads, Caliper.



DISK BRAKE

In this report I would be hoping to elaborate more about the brake disc (rotor) and how it is manufactured, the materials used and its quality and defects compared to other brake.

Disc brake is an assembly product and these parts are manufactured separately through different procedure to one another.

EQUIPMENT/TOOLS USED FOR MANUFACTURING

The equipment's and tools used in this process will be talked more about in the manufacturing details section of this report but some of the main tools used in as follows:

- Permanent molds
- Crucibles
- Drilling machines
- Computer guided machines

Chemical composition:

Hardness -Hardness is the resistance to surface indentation (e.g., a local dent or scratch). Thus, it is a measure of plastic deformation. The Hardness of the composites samples were measured using a Leitz, Brinnel hardness measuring machine with a load of 100 N. The specimen prepared as per ASTM standard and the dimension of the specimen is 19X19 mm Wear--Wear test is carried out with pin-on disc setup with ASTM standard dimension. To check the wear rate on different loading conditions.

COMPARISON OF MECHANICAL PROPERTIES

It is observed from the comparison of results that the mechanical properties of hybrid aluminum composite is superior to the monolithic Aluminum metal.

FA % +Sic %	UTS in N
0	320
9% Sic+15% FA	412

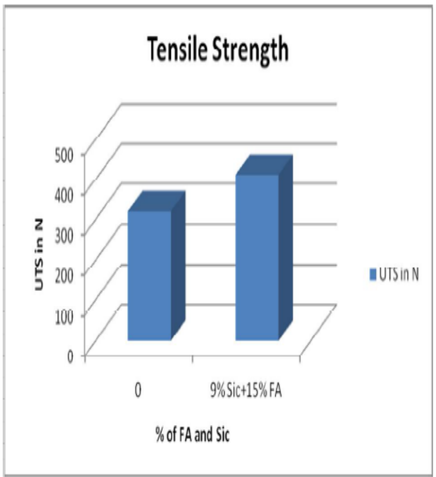
(c)

Weight loss due to wear		
Load	Base Metal	Sic 9 % + Fa 15 %
50	0.003	0.002
100	0.009	0.0039
150	0.019	0.0071

(d)

FA % +Sic %	Hardness in Kgf
0	50
9% Sic+15% FA	71

(e)



THE MODEL DESIGN AND BRAKING CONDITIONS

Design Consideration

- Brake Power
- Larger diameter rotors more will be brake power with the same amount of clamp force than a smaller diameter rotor.
- The higher the coefficient of friction for the pad, the more brake power will be generated
- Dynamic Coefficient Of Friction
- Type of material used for the brake rotor.
- Speed Sensitive – Coefficient of friction typically drops as the speed of the vehicle increases
- Pressure Sensitive - Coefficient of friction typically drops as more clamp force is generated.
- Temperature Sensitive - Coefficient of friction typically drops as the temperature of the brake system increases.
- □Surface Area – The more surface area available on a brake system, the better heat dissipation will be via convection.

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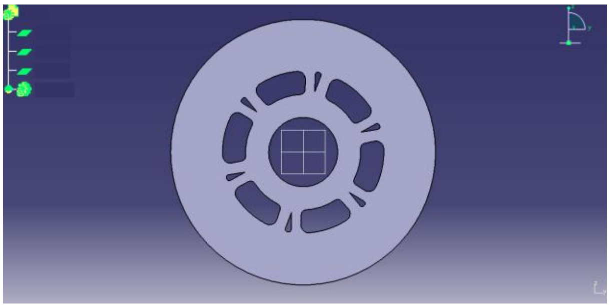
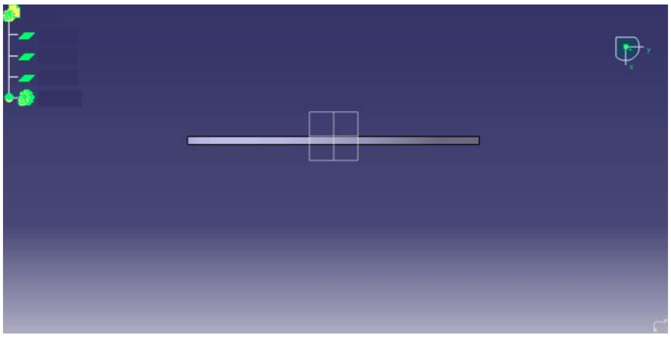
- Material Selection– Material selection is important in trying to control where the heat dissipates once generated
- Wear –wear is proportional to pressure intensity (p) and relative velocity (v) which is proportional to radius. Thus W=k p r
- Thermal Mass –Must have enough material mass to properly handle the temperatures during braking applications. This is limited by size and weight.



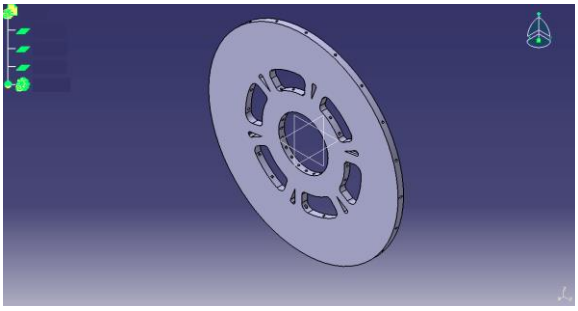
Front View

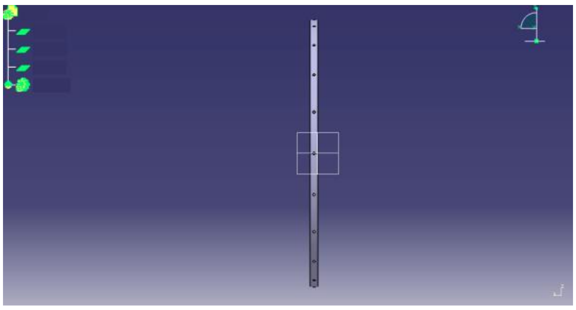


Side View

New Design:

Isometric view and side view





THERMAL ANALYSIS:

Thermal L Analysis is probably the most common application of the finite element method. Thermal analysis to calculate the heat flux, temperature gradient & temperature variation. For finite element Analysis of Engine Head, SOLID92- Tetrahedral element has been used.

RESULT VALUES FOR NORMAL CHEMICAL COMPOSITION OF Fe

(Carbon (C) and silicon (Si) 2.1–4 wt. % and 1–3 wt%, Remaining iron

IMPORTING GEOMETRY:

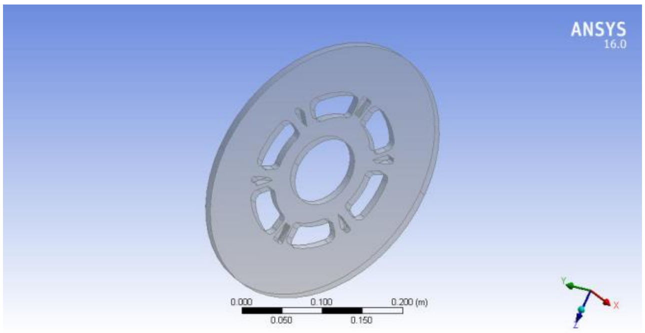
Material Data

Cast Iron

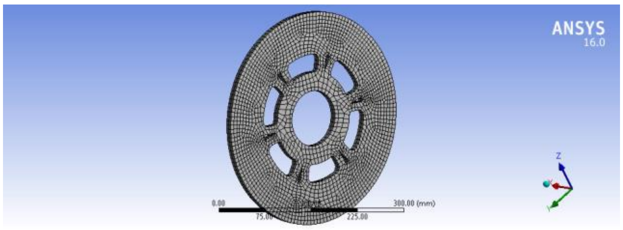
TABLE

Cast Iron > Constants

Thermal Conductivity	8.3e-002 W mm^-1 C^-1
Density	7.2e-006 kg mm^-3
Specific Heat	1.65e+005 mJ kg^-1 C^-1



Meshing Geometry:



Object Name	Mesh
State	Solved
Display	
Display Style	Body Color
Defaults	
Physics Preference	Mechanical
Relevance	0
Sizing	
Use Advanced Size Function	Off
Relevance Center	Medium
Element Size	Default
Initial Size Seed	Active Assembly
Smoothing	Medium
Transition	Fast
Span Angle Center	Coarse
Minimum Edge Length	5.0 mm

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Inflation	
Use Automatic Inflation	None
Inflation Option	Smooth Transition
Transition Ratio	0.272
Maximum Layers	5
Growth Rate	1.2
Inflation Algorithm	Pre
View Advanced Options	No
Patch Conforming Options	
Triangle Surface Mesher	Program Controlled
Patch Independent Options	
Topology Checking	No
Advanced	
Number of CPUs for Parallel Part Meshing	Program Controlled
Shape Checking	Standard Mechanical
Element Midside Nodes	Program Controlled
Straight Sided Elements	No
Number of Retries	0
Extra Retries For Assembly	Yes
Rigid Body Behavior	Dimensionally Reduced
Mesh Morphing	Disabled
Defeaturing	
Statistics	
Nodes	24016
Elements	4040
Mesh Metric	None

Steady-State Thermal (A5)

TABLE
Model (A4) > Analysis

Object Name	Steady-State Thermal (A5)
State	Solved
Definition	
Physics Type	Thermal
Analysis Type	Steady-State
Solver Target	Mechanical APDL
Options	
Generate Input Only	No

TABLE 7
Model (A4) > Steady-State Thermal (A5) > Initial Condition

Object Name	Initial Temperature
State	Fully Defined
Definition	
Initial Temperature	Uniform Temperature
Initial Temperature Value	22. °C

TABLE 8
Model (A4) > Steady-State Thermal (A5) > Analysis Settings

Object Name	Analysis Settings
State	Fully Defined
Step Controls	
Number Of Steps	1.
Current Step Number	1.
Step End Time	1. s
Auto Time Stepping	Program Controlled
Solver Controls	
Solver Type	Program Controlled
Solver Pivot Checking	Program Controlled
Radiosity Controls	
Radiosity Solver	Program Controlled
Flux Convergence	1.e-004
Maximum Iteration	1000.
Solver Tolerance	1.e-007 W/mm²
Over Relaxation	0.1
Hemicube Resolution	10.
Nonlinear Controls	
Heat Convergence	Program Controlled
Temperature Convergence	Program Controlled
Line Search	Program Controlled
Output Controls	
Calculate Thermal Flux	Yes
General Miscellaneous	No
Store Results At	All Time Points
Analysis Data Management	
Future Analysis	None
Scratch Solver Files Directory	
Save MAPDL db	No
Delete Unneeded Files	Yes
Nonlinear Solution	Yes
Solver Units	Active System
Solver Unit System	Nmm

BOUNDARY CONDITION:

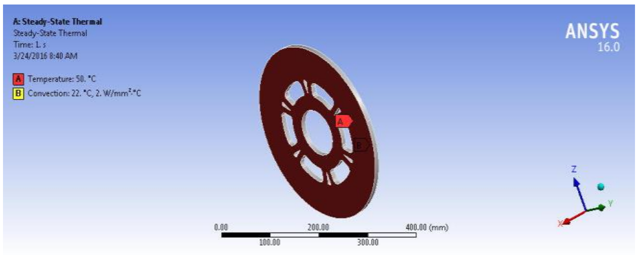

TABLE
Model (A4) > Steady-State Thermal (A5) > Loads

Object Name	Temperature	Convection
State	Fully Defined	
Scope		
Scoping Method	Geometry Selection	
Geometry	1 Face	26 Faces
Definition		
Type	Temperature	Convection
Magnitude	50. °C (ramped)	
Suppressed	No	
Film Coefficient		Tabular Data
Coefficient Type		Average Film Temperature
Ambient Temperature		22. °C (ramped)
Convection Matrix		Program Controlled
Edit Data For		Film Coefficient
Tabular Data		
Independent Variable		Temperature
Graph Controls		
X-Axis		Temperature

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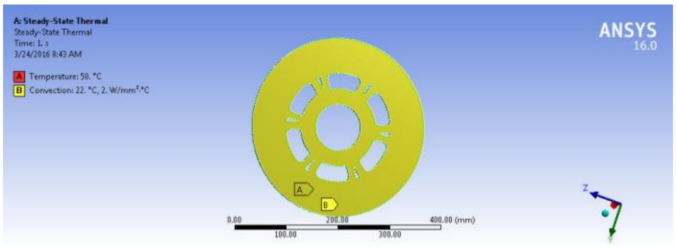
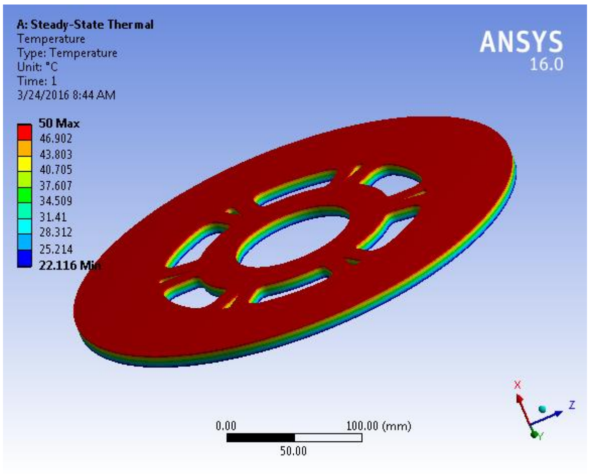


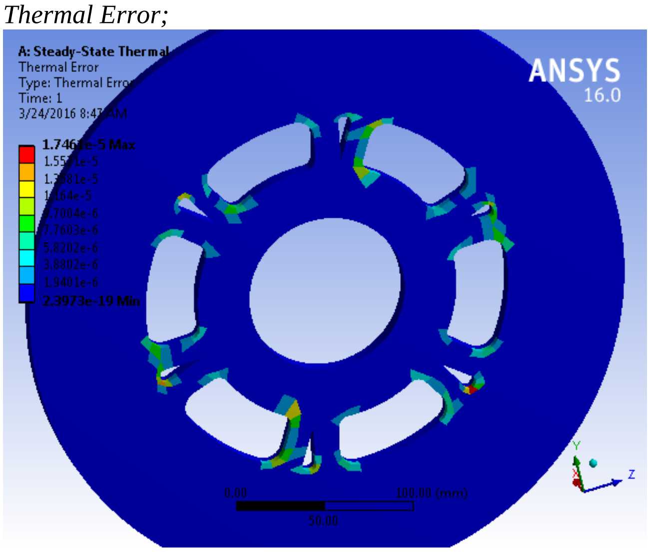
6. RESULT VALUES:

Thermal Distribution



Results	
Minimum	22.116 °C
Maximum	50. °C

Thermal Error;



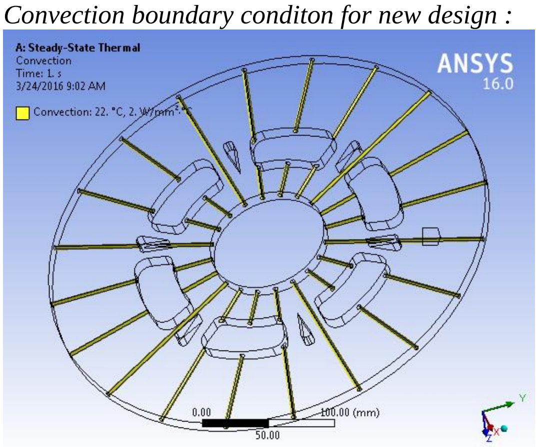
Model (A4) > Steady-State Thermal (A5) > Solution (A6) > Results

Object Name	*Temperature*	*Total Heat Flux*	*Thermal Error*
State	Solved		
Scope			
Scoping Method	Geometry Selection		
Geometry	All Bodies		
Definition			
Type	Temperature	Total Heat Flux	Thermal Error
Results			
Minimum	22.116 °C	0.23144 W/mm²	2.3973e-019
Maximum	50. °C	0.23144 W/mm²	1.7461e-005

RESULT OF MODIFIED DESIGN:

Analysis Result for disc brake which is having hole in with of disk brake which is pass through inner part of the disc by using components we analyzed and result are defined.

Convection boundary conditon for new design :



Temperature distribution ;

Object Name	*Temperature*	*Thermal Error*
State	Solved	
Scope		
Scoping Method	Geometry Selection	
Geometry	All Bodies	
Definition		
Type	Temperature	Thermal Error
Results		
Minimum	19.603 °C	0.22596
Maximum	50. °C	49900

Design	**Maximum temperature**	**Minimum temperature**
Without Hole	**50°**	**22°**
With Hole	**50°**	**19°**

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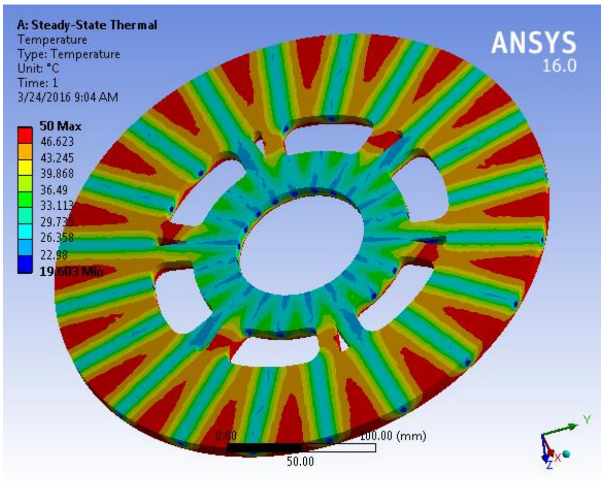

Thermal error:
Model (A4) > Steady-State Thermal (A5) > Solution (A6) > Resu

CONCLUSION

By this method the life time of the disc wheel can be increased in a specific manner. It is also has many advantages in the modern world since the cost of the disc brake in future will be in higher most position so by applying the modern techniques and modern methods the efficiency and life time is increased because of prevention of hot spots. Our Analysis of Disc Brake on the sport bikes enhances the perfect result to the desired level. The method can be applied by changing the structure either by changing the composition of disc wheel. The structure of the disc wheel can be changed by drilling the hole in the upper most position in the specific diameter.

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