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Design and Thermal Analysis of Disc Brake for Sports Bikes

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ABSTRACT:
At the IAA in Frankfurt in 1999, the carbon-ceramic brake disk had its world premiere. The use of the high-tech material had revolutionized the brake technology: In comparison to the conventional grey cast iron brake disk the carbon-ceramic brake disk weighed round 50 per cent less reducing the unsprang mass by almost 20 kilograms. Further significant advantages are: improved brake response and fading data, high thermal stableness, no hot judder, excellent pedal feel, improved steering behaviour, high abrasion resistance and thus longer life time and the advantage of avoiding almost completely brake dust. At first Porsche AG built the carbon-ceramic brake disk in 2001 into the 911 GT2 as series equipment. Since that time also other premium brands use the advantages of this innovative brake technology for more security and comfort. These are for example sports cars and luxury class limousines from Audi, Bentley, Bugatti and Lamborghini.

In this paper we will design a disk break using carbon ceramic composite for high speed two wheelers. The main aim of this paper is to design a composite disk break with least possible production cost and long life, for achieving this goal we will compare different models of structural models of disk brakes with different materials finally we conclude the best model and material based on the thermal behaviour and stress concentrations of each model, for designing disk brakes we use Catia V5 R20, and for analysis we use Ansys 15.0.

INTRODUCTION

Brake

Brake is a Mechanical Device used to stop or slowing down the Vehicle or a body in motion. A disc brake is a type of brake that utilizes calipers to clutch pairs of pads alongside a disc in arrange to create friction that retards the rotary motion of a shaft, for instance a vehicleaxle, moreover to retard its rotational speed or to seize it stationary.Hydraulic disc brakes are the a large amount universally used form of brake for motor vehicles but the ideology of a disc brake are appropriate to almost any rotating shaft. Brakes generally use friction amid two surfaces hard-pressed together to renovate the kinetic energy of the moving vehicle or body into heat.

Brakes may be described as using friction, pumping, or electromagnetic. One brake may use a number of principles: for instance, a pump may pass fluid through an orifice to create friction.

Mechanical brakes are most common and can be divided broadly into shoe or pad brakes, using an open have on surface, and hydrodynamic brakes, such as parachutes, which use friction in a working fluid and do not overtly wear. Classically the term "friction brake" is named to mean shoe brakes and excludes hydrodynamic brakes, still while hydrodynamic brakes use friction. Friction brakes are frequently revolving devices with a motionless pad and a rotating wear exterior. ordinary configurations comprise shoes that bond to rub on the outside of a rotating throb, such as a band brake; a rotating throb with shoes that expand to rub the inside of a drum, regularly called a "drum brake", even if other drum patterns are possible; and pads that touch a rotating disc, usually termed as “disc brake”. Other brake configurations are used, but less frequently.

A drum brake is a vehicle brake in which the friction is sourced by a set of brake shoes that push against the inner surface of a rotating drum. The drum is associated to the rotating wheel center.

The disc brake is a machine or device for retarding or stopping the rotation of a Vehicle in motion. A rotor usually made of cast iron or ceramic, is connected to the wheel. To retard the wheel, friction substance in the form of brake pads associated in a device termed as brake caliper is enforced mechanically, hydraulically, pneumatically or electromagnetically against together

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sides of the disc. Friction sources the disc and attached wheel to retard or stop.

MATERIAL DATA

AL_2O_3

AL2O3 > Constants

Density	2.25e-006 kg m^-3
Thermal Conductivity	24 W m^-1 C^-1
Specific Heat	707.7 J kg^-1 C^-1

AL2O3 > Isotropic Elasticity

Temperature C	Young's Modulus Pa	Poisson's Ratio	Bulk Modulus Pa	Shear Modulus Pa
	3.7e+005	0.22	2.2024e+005	1.5164e+005

CARBON-CARBON COMPOSITES

Carbon-carbon composites > Constants

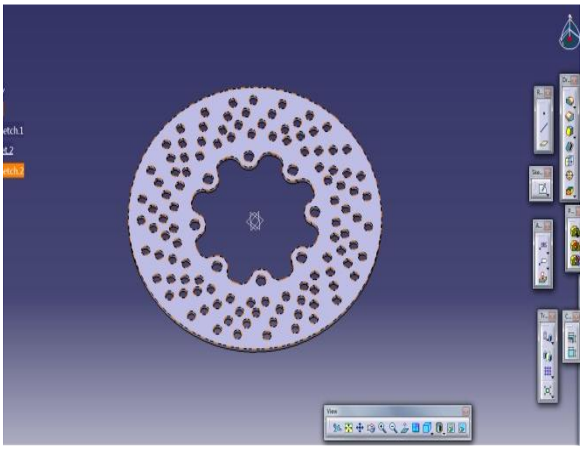
Density	1800 kg m^-3
Thermal Conductivity	40 W m^-1 C^-1

Carbon-carbon composites > Isotropic Elasticity

Temperature C	Young's Modulus Pa	Poisson's Ratio	Bulk Modulus Pa	Shear Modulus Pa
	9.5e+010	0.31	8.3333e+010	3.626e+010

DESIGN OF THE DISC BRAKES

MODEL 1



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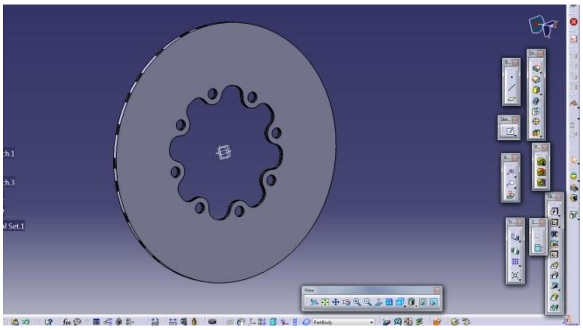

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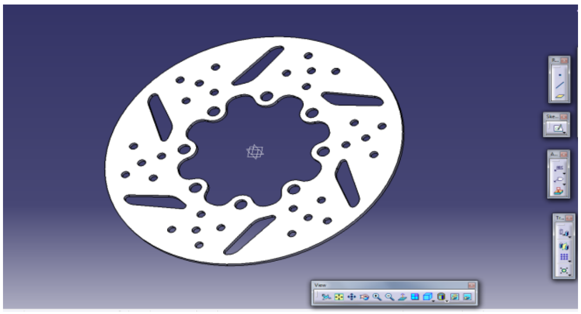
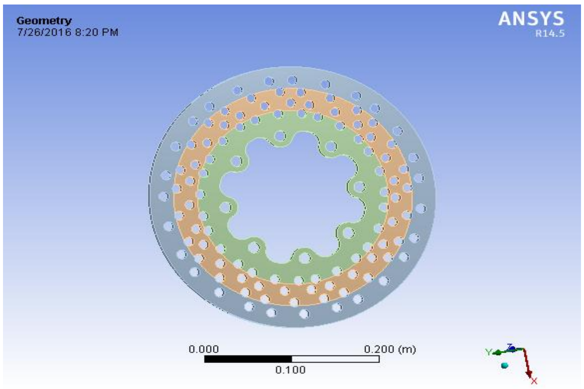


ANALYSIS OF A DISC BRAKE OF ORIGINAL MODEL WITH AL_2O_3

GEOMETRY



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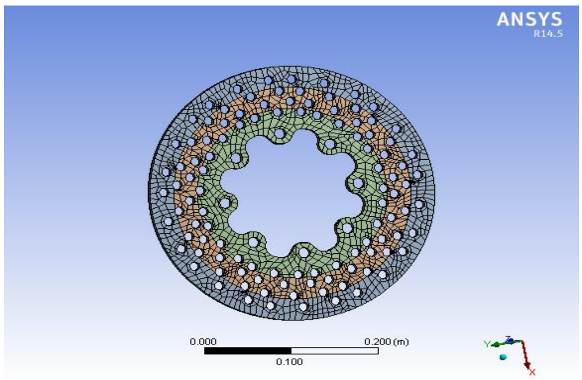

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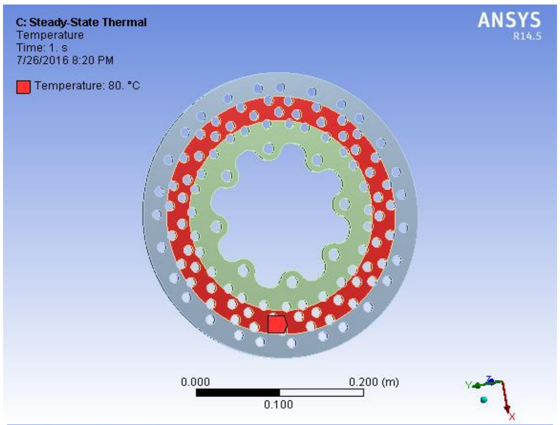
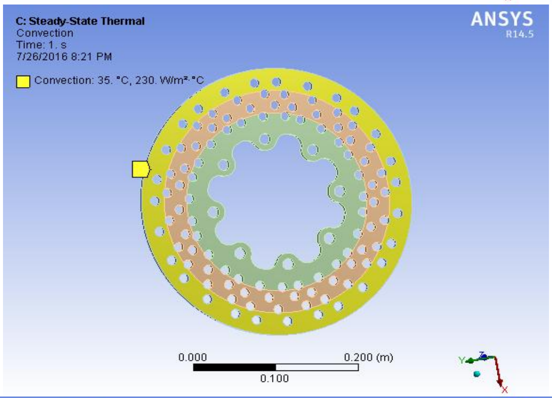
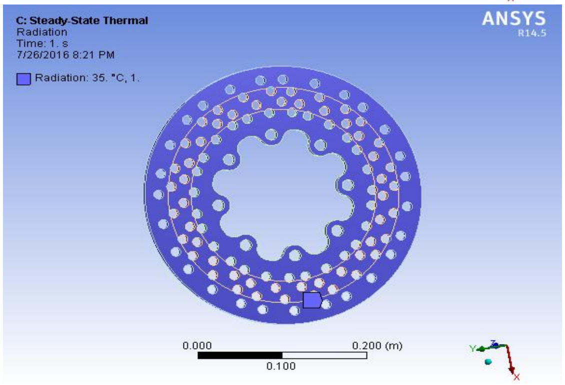
STEADY-STATE THERMAL







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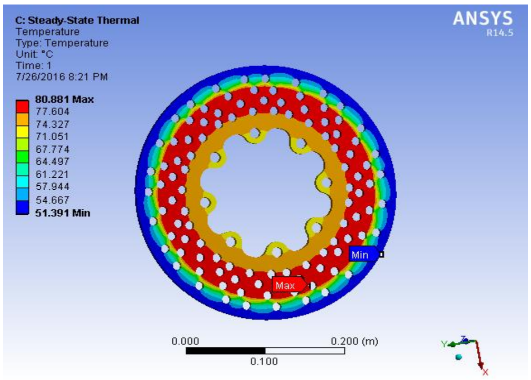

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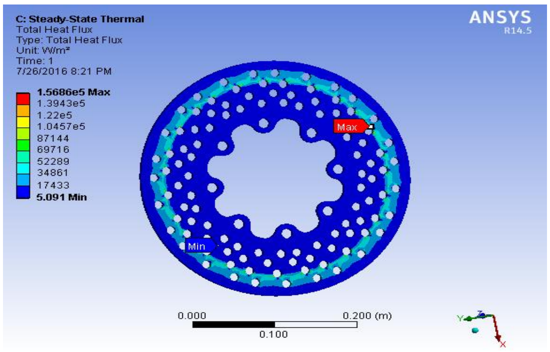

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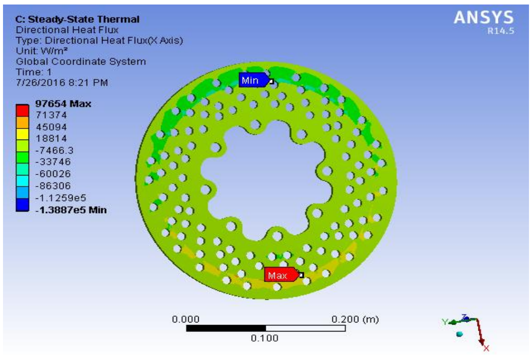

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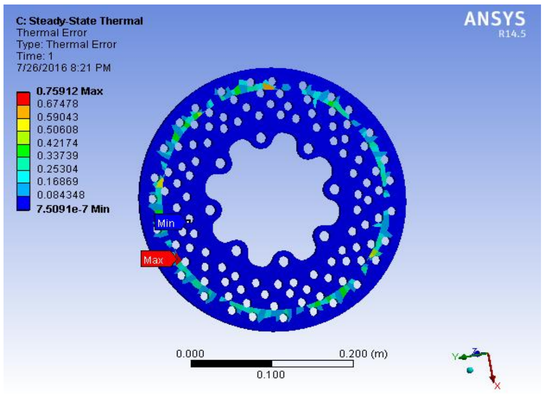

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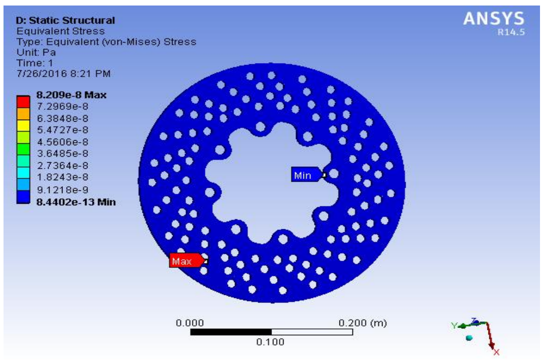

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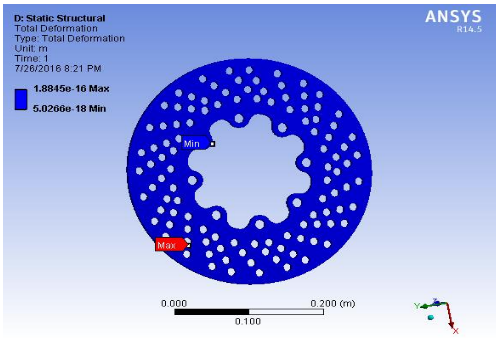
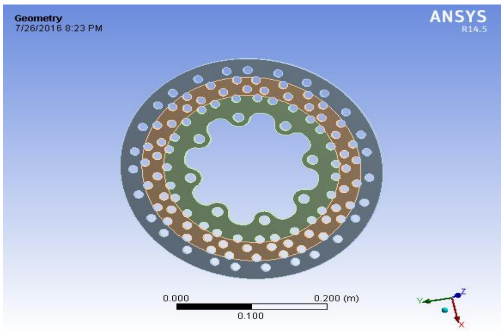


ANALYSIS OF A DISC BRAKE OF MODEL - 1 WITH CARBON – CARBON

GEOMETRY



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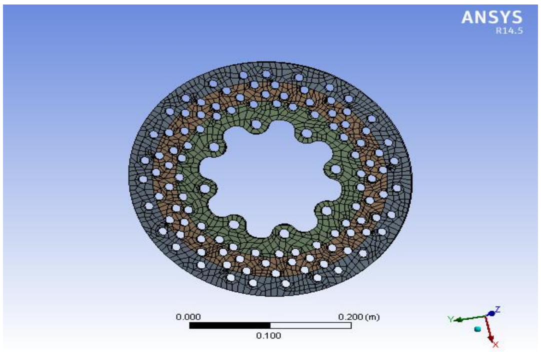

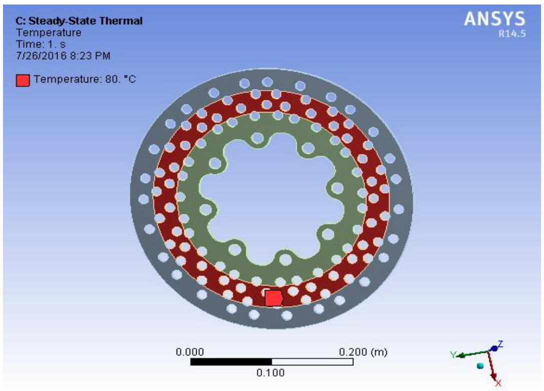

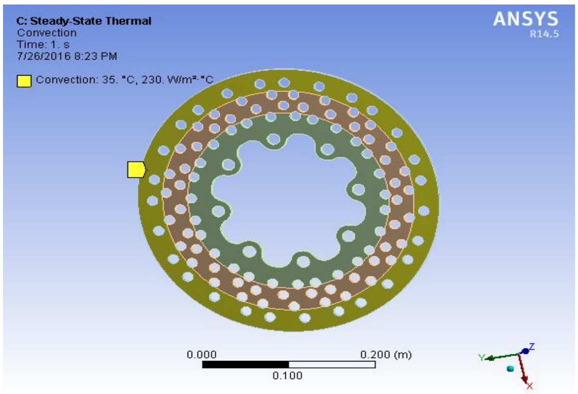

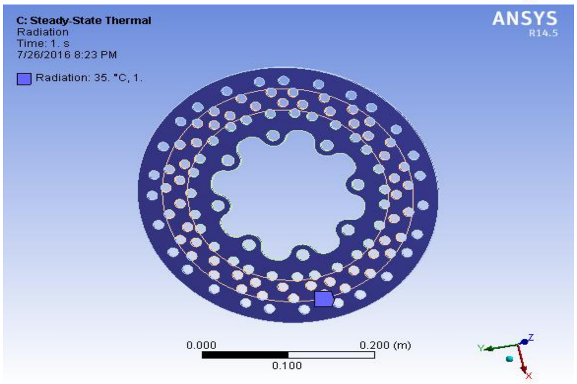

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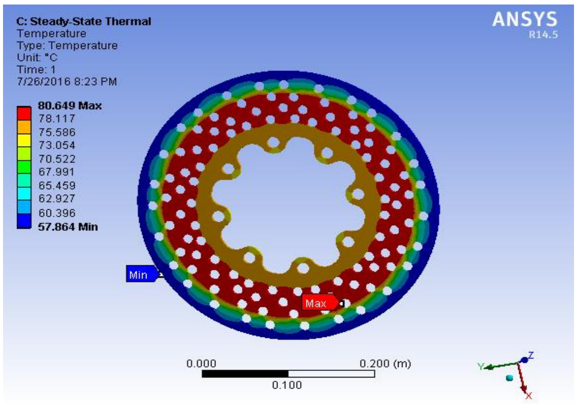

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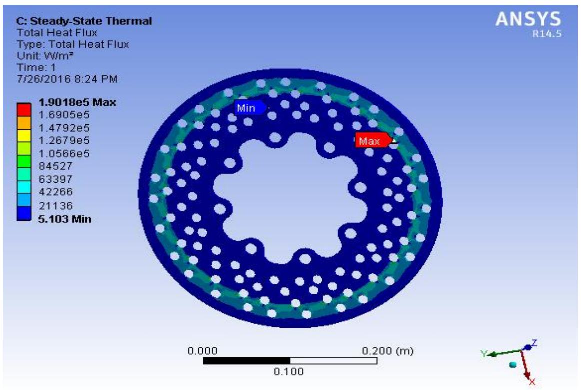

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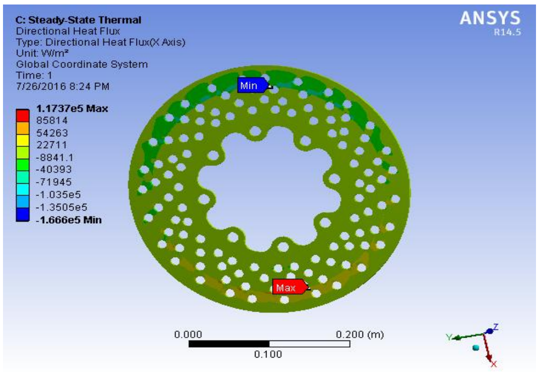

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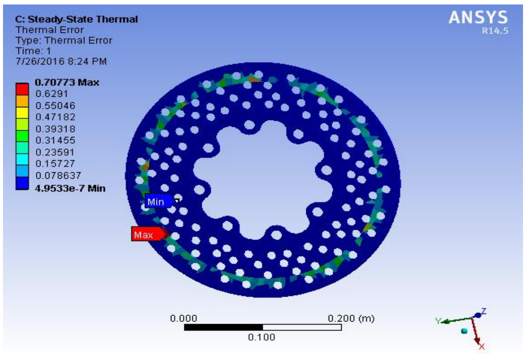

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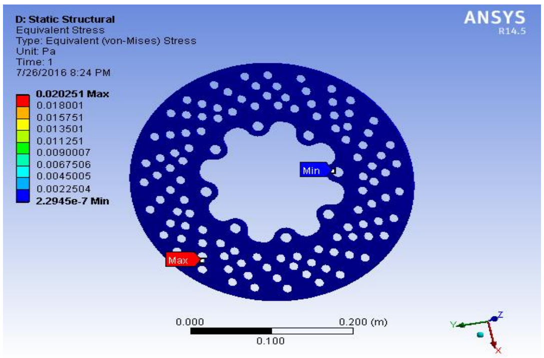

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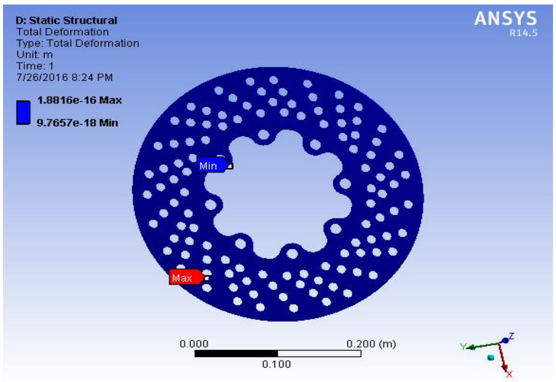

ANALYSIS OF A DISC BRAKE OF MODEL - 2 WITH AL_2O_3

IMPORTED FILE IN TO ANSYS

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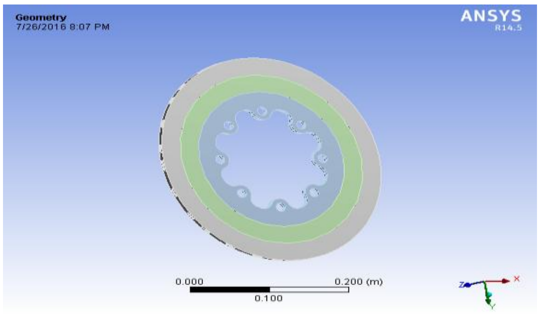

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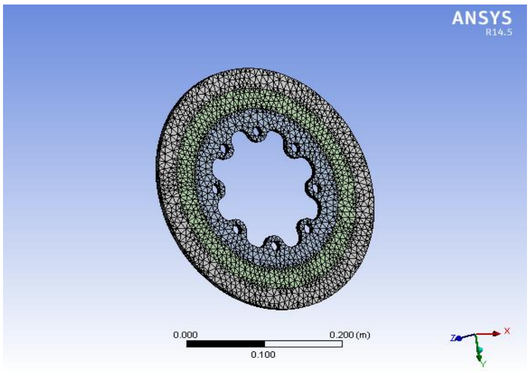

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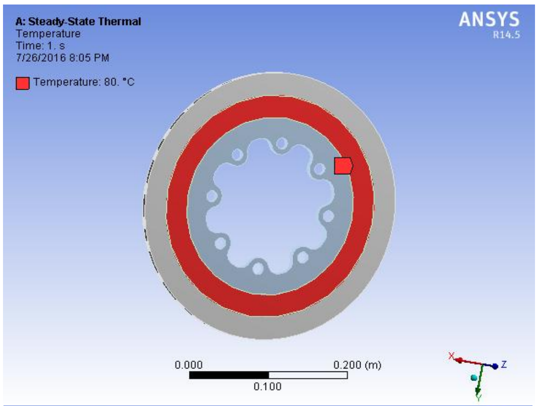

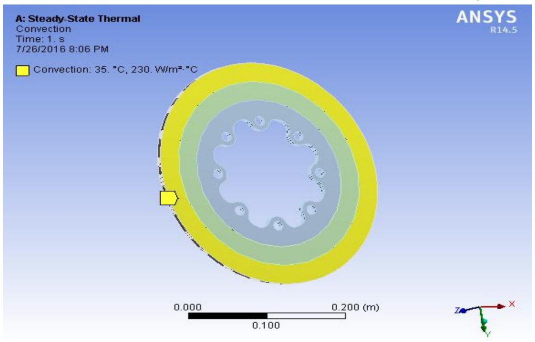

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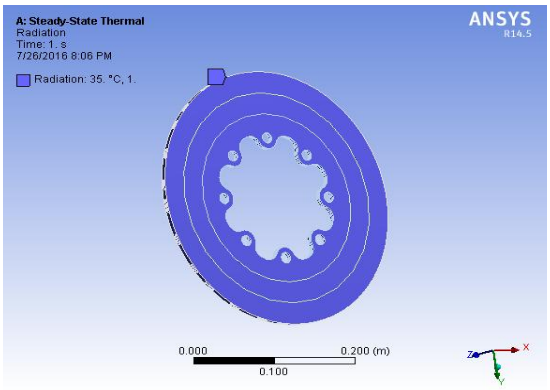

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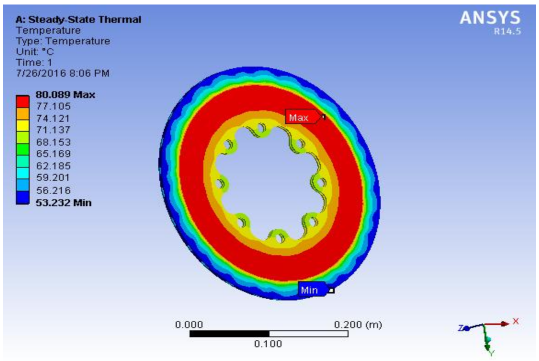

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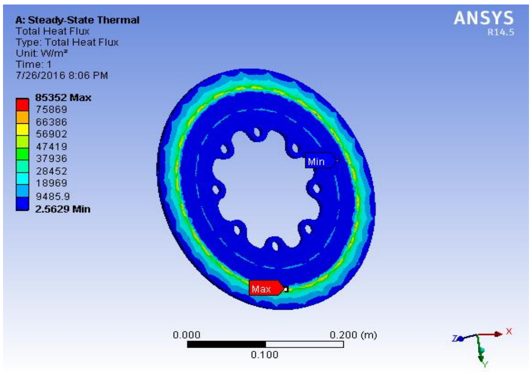

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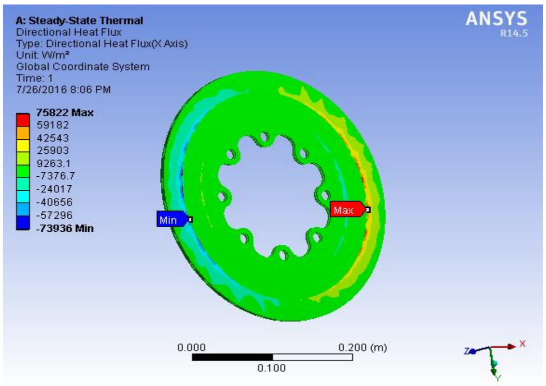

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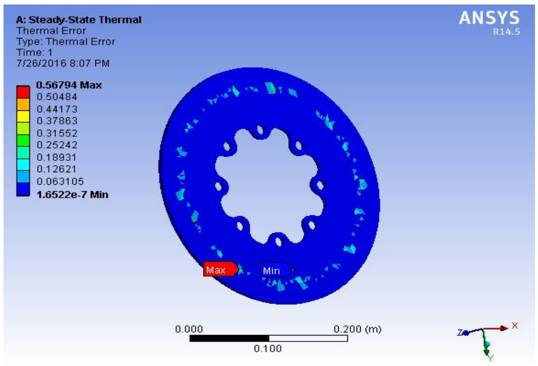

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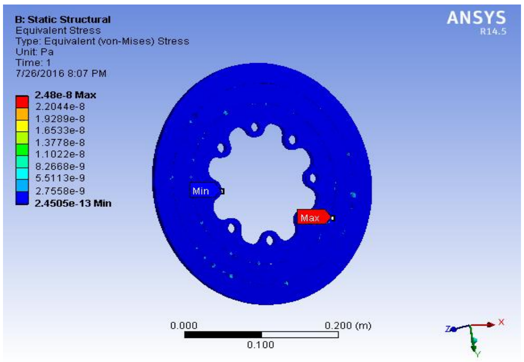

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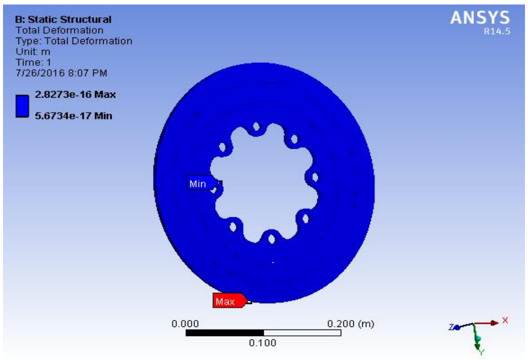
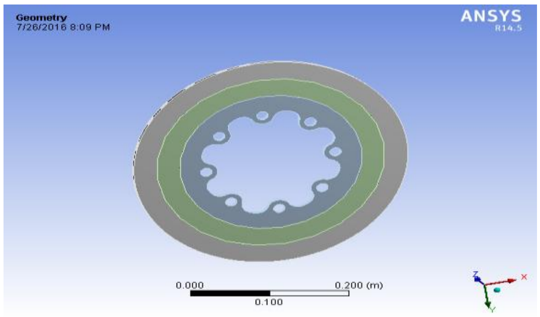


ANALYSIS OF A DISC BRAKE OF MODEL - 2 WITH CARBON – CARBON COMPOSITES GEOMETRY



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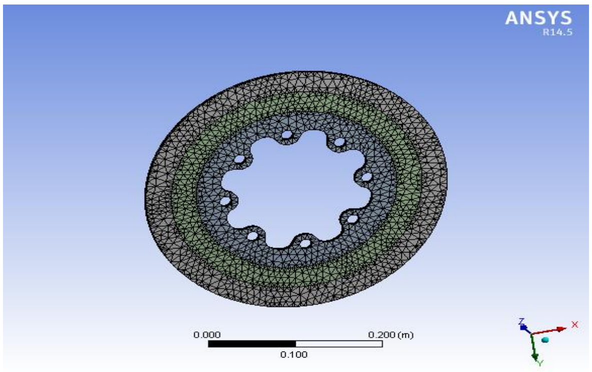
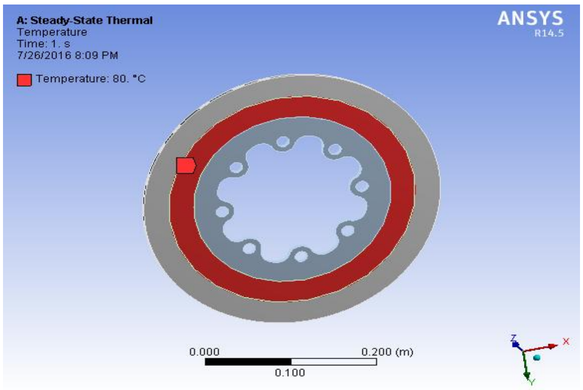
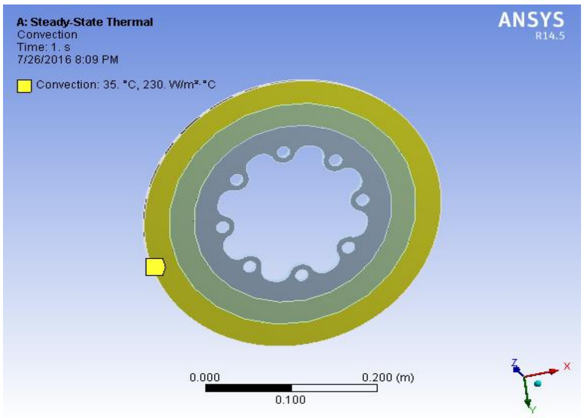
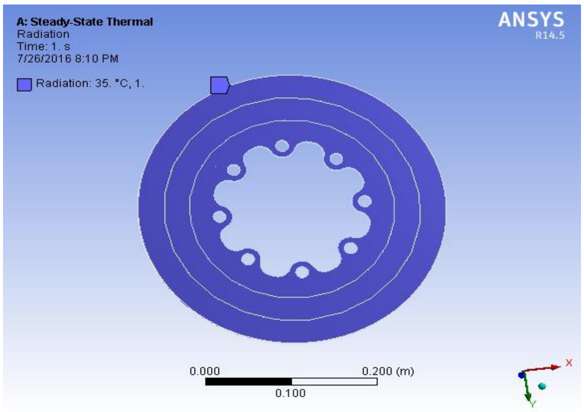
MESH



STEADY-STATE THERMAL







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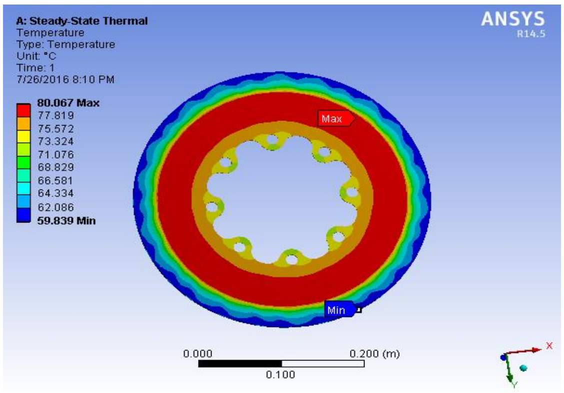

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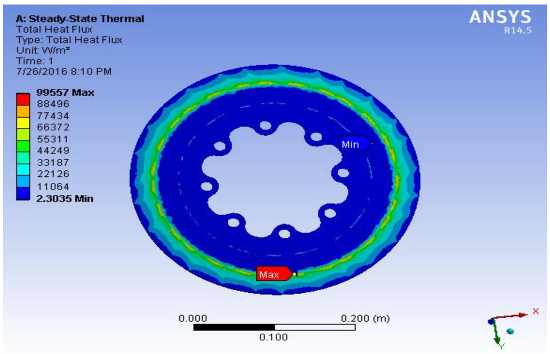

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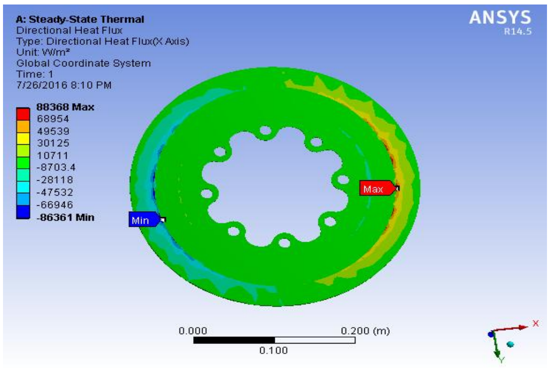

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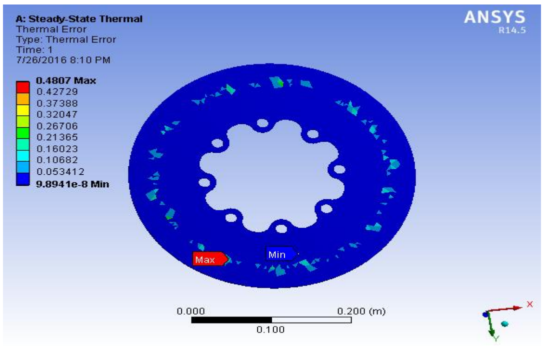

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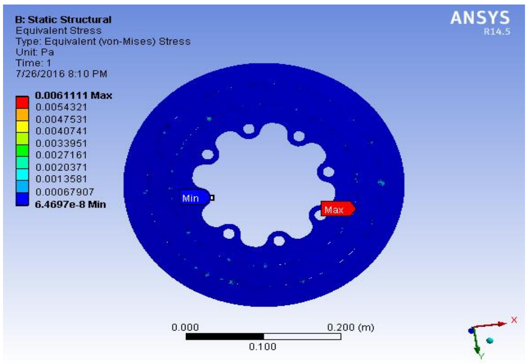
THERMAL STRESS



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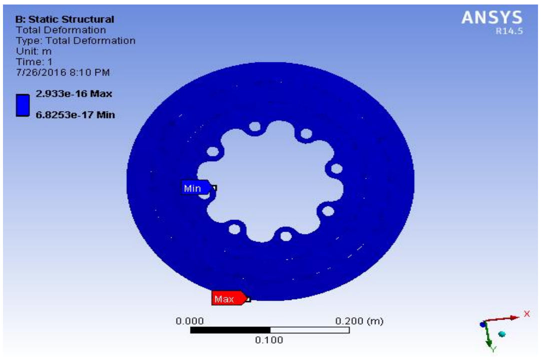
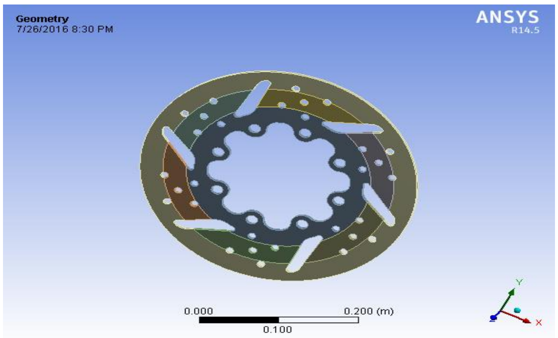


ANALYSIS OF A DISC BRAKE OF MODEL - 3 WITH AL_2O_3

GEOMETRY



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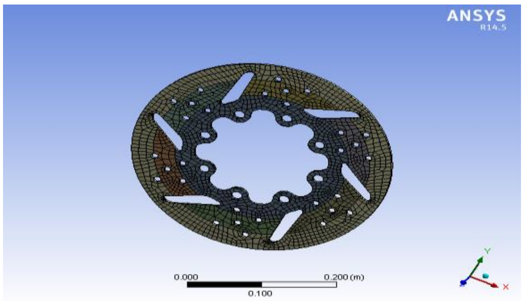
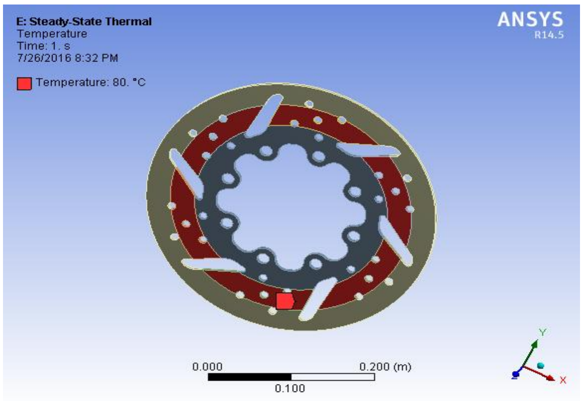
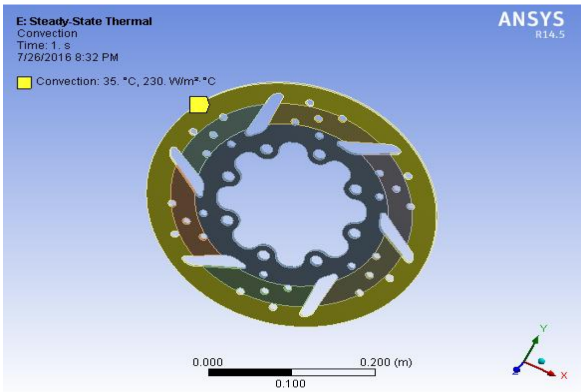
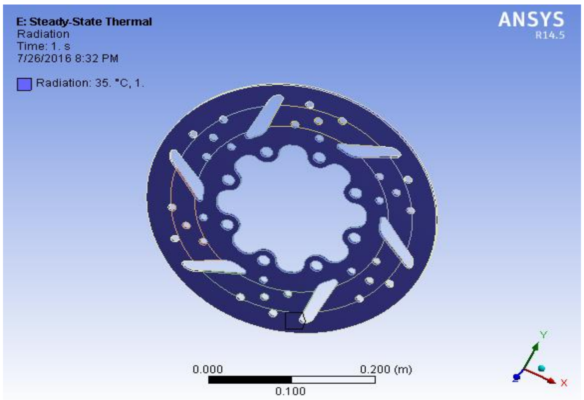


STEADY-STATE THERMAL







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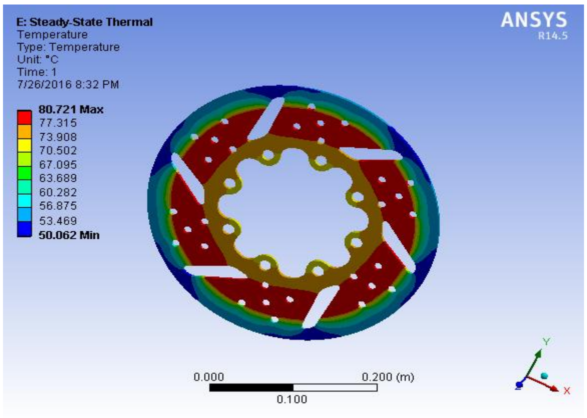

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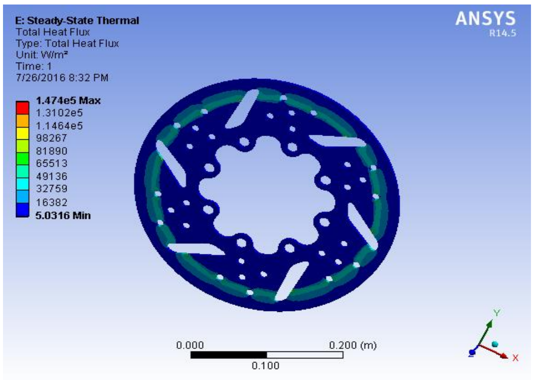
TOTAL HEAT FLUX



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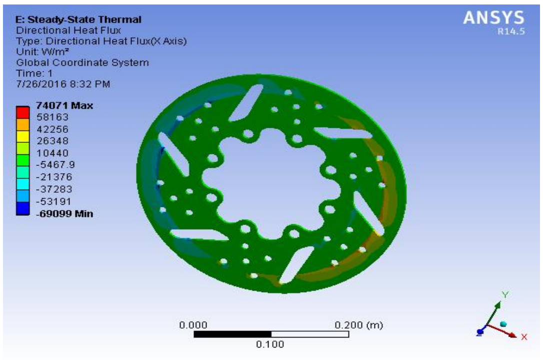

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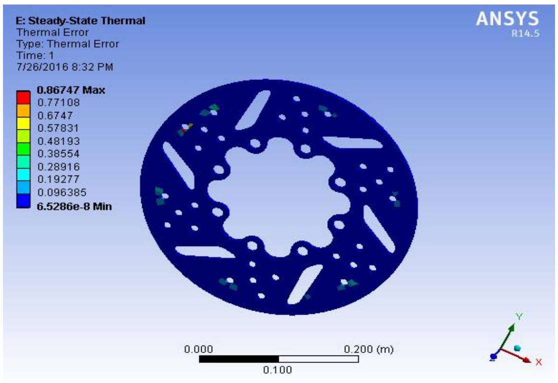

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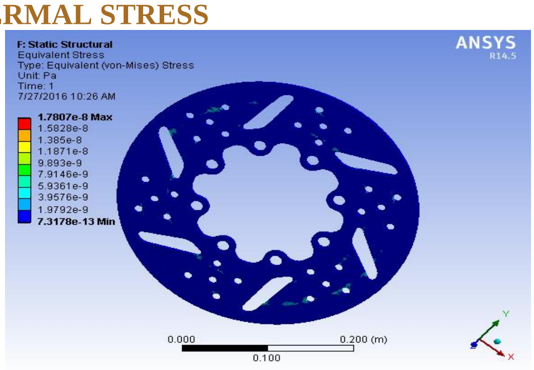

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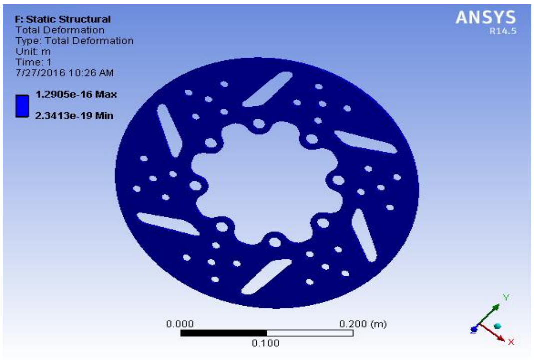
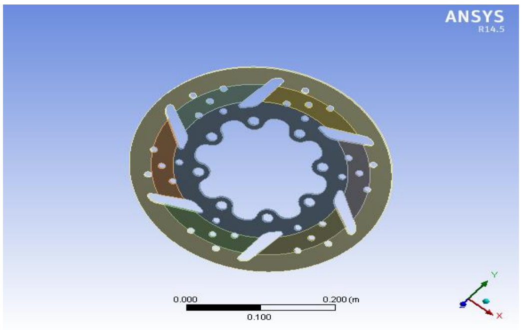


ANALYSIS OF A DISC BRAKE OF MODEL - 3 WITH CARBON – CARBON GEOMETRY



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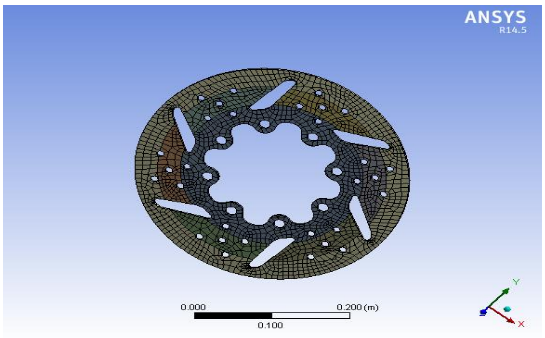
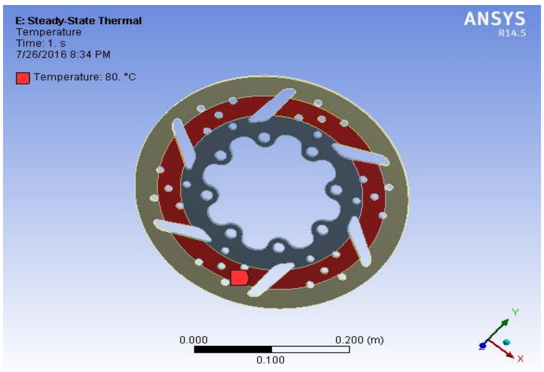


STEADY-STATE THERMAL



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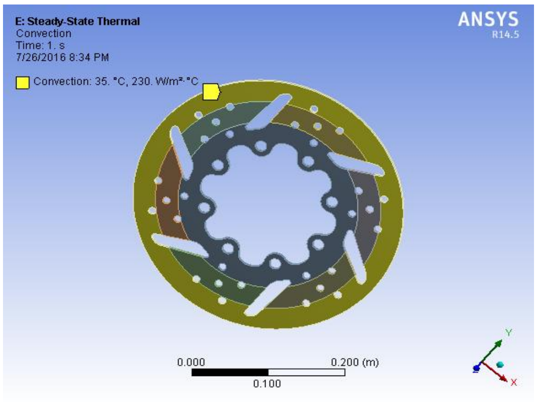
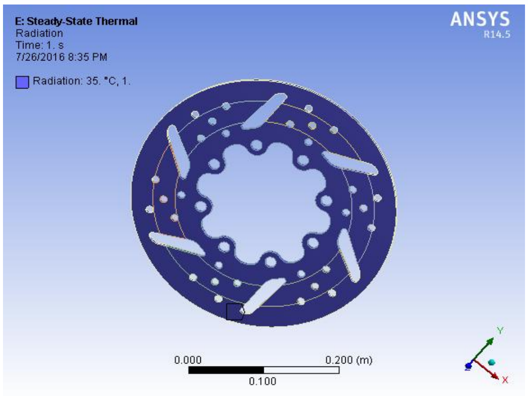
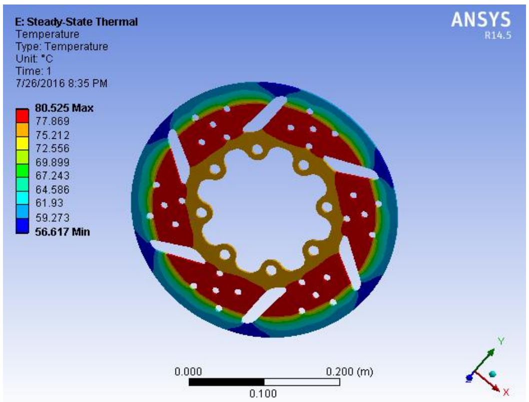
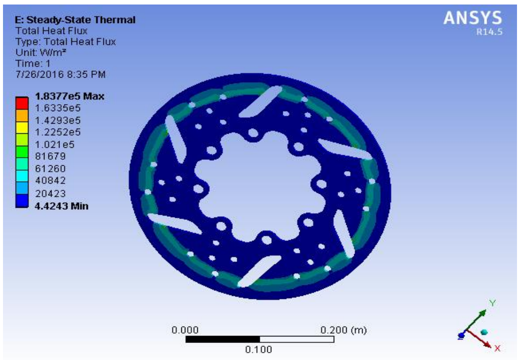




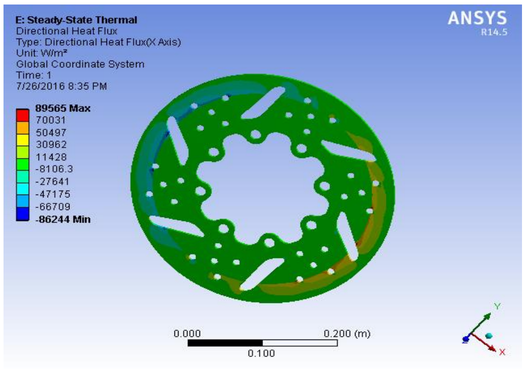
TEMPERATURE



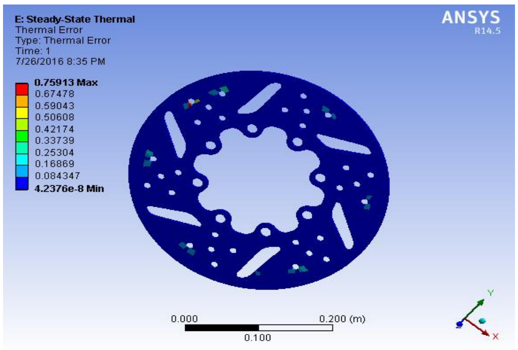
TOTAL HEAT FLUX



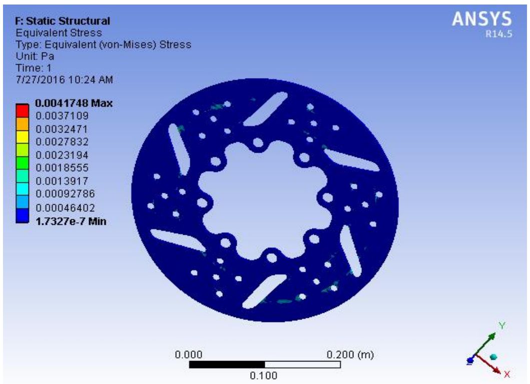
DIRECTIONAL HEAT FLUX



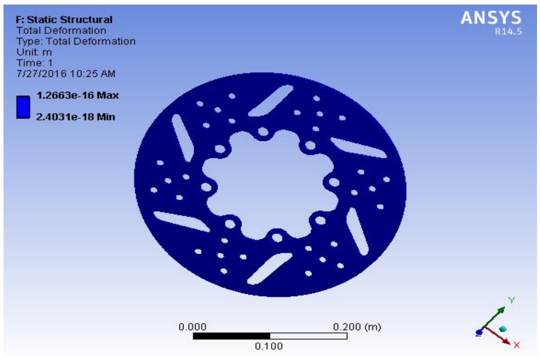
THERMAL ERROR



THERMAL STRESS



DEFORMATION



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TABLES

RESULT TABLE FOR MODEL 1:

		AL_2O_3/SIC	CARBON CARBON COMPOSITES
TEMPERATURE	MIN	51.391	57.864
	MAX	80.881	80.649
TOTAL HEAT FLUX	MIN	5.091	5.103
	MAX	$1.5686E^{5}$	$1.9018E^{5}$
DIRECTIONAL HEAT FLUX	MIN	$-1.3887E^{5}$	$-1.666E^{5}$
	MAX	97654	$1.1737E^{5}$
THERMAL ERROR	MIN	$7.5091E^{-7}$	$4.9533E^{-7}$
	MAX	0.75912	0.70773
THERMAL STRESS	MIN	$8.4402E^{-13}$	$2.2945E^{-7}$
	MAX	$8.209E^{-8}$	0.020251
DEFORMATION	MIN	$5.0266E^{-18}$	$9.7657E^{-18}$
	MAX	$1.8845E^{-16}$	$1.8816E^{-16}$

RESULT TABLE FOR MODEL 2:

		AL_2O_3/SIC	CARBON CARBON COMPOSITES
TEMPERATURE	MIN	53.232	59.839
	MAX	80.089	80.067
TOTAL HEAT FLUX	MIN	2.5629	2.3035
	MAX	85352	99557
DIRECTIONAL HEAT FLUX	MIN	-73936	-86361
	MAX	75822	88368
THERMAL ERROR	MIN	$1.6522E^{-7}$	$9.8941E^{-8}$
	MAX	0.56794	0.4807
THERMAL STRESS	MIN	$2.4505E^{-13}$	$6.4697E^{-8}$
	MAX	$2.48E^{-8}$	0.0061111
DEFORMATION	MIN	$5.6734E^{-17}$	$6.8253E^{-17}$
	MAX	$2.8273E^{-16}$	$2.933E^{-16}$

RESULT TABLE FOR MODEL 3:

		AL_2O_3/SIC	CARBON CARBON COMPOSITES
TEMPERATURE	MIN	50.062	56.617
	MAX	80.721	80.525
TOTAL HEAT FLUX	MIN	5.0316	4.4243
	MAX	$1.474E^{5}$	$1.8377E^{5}$
DIRECTIONAL HEAT FLUX	MIN	-69099	-86244
	MAX	74071	89565
THERMAL ERROR	MIN	$6.5286E^{-8}$	$4.2376E^{-8}$
	MAX	0.86747	0.75713
THERMAL STRESS	MIN	$7.3178E^{-13}$	$1.7327E^{-7}$
	MAX	$1.7807E^{-8}$	0.0041748
DEFORMATION	MIN	$2.3413E^{-19}$	$2.4031E^{-18}$
	MAX	$1.2905E^{-16}$	$1.2663E^{-16}$

CONCLUSION

In this paper we will design 3 different models of disk brake using carbon - carbon composite for high speed two wheelers. The main aim of this paper is to design a composite disk brake with least possible production cost and long life, for achieving this goal we will compare different models of structural models of disk brakes with different materials.

Here we have designed the disc brake using Catia V5, and thermal analysis is done in Ansys to the different models and the results are verified in a graph and tables.

As we observe in the first model the analysis is done with 2 materials i.e. with CARBON CARBON COMPOSITES and AL2O3/SIC. As we observe in the results the material with CARBON - CARBON COMPOSITES is the best product which increases the life as we compare the results in the heat flux, thermal error, temperatures and thermal stress. So we can conclude that the material CARBON - CARBON COMPOSITES is the best output for **Model 1**

As we observe in the first model the analysis is done with 2 materials i.e. with CARBON CARBON COMPOSITES and AL2O3/SIC. As we observe in the

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results the material with CARBON - CARBON COMPOSITES is the best product which increases the life as we compare the results in the heat flux, thermal error, temperatures and thermal stress. So we can conclude that the material CARBON - CARBON COMPOSITES is the best output for **Model 2**

As we observe in the first model the analysis is done with 2 materials i.e. with CARBON CARBON COMPOSITES and AL2O3/SIC. As we observe in the results the material with CARBON - CARBON COMPOSITES is the best product which increases the life as we compare the results in the heat flux, thermal error, temperatures and thermal stress. So we can conclude that the material CARBON - CARBON COMPOSITES is the best output for **Model 3**

As we compare the 3 different models and their results for the best material outputs, here by comparing the obtained results we can conclude that the material CARBON - CARBON COMPOSITES with the model 2 is the better product for the better life.

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