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Modeling and Analysis of Disc Brake

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Abstract—**The aim of this paper is to design and analysis of a disc and analysis made with some different materials which are having slightly different properties by using simulation of ANSYS software. They are Aluminum alloy, titanium alloy and gray cast iron. Concentrated firstly on steady state temperature of disc under the temperature of 40^{o}c and secondly the comparison of the materials mentioned above with their capability to withstand for the temperature. Which experiences the temperature around 19 ^{0}C to 40 ^{0}C through a compressible air medium by using the ANSYS software, it is paved to analyze and created the replica of a disc as non circular among many shapes because of good temperature distribution, high convection and heat dissipation properties. Out of these materials the aluminum material is having optimum temperature range of 21.2^{o}c (Min) and 40^{o}c (Max). Along with these materials aluminum alloy having better properties which is now a days most popularly used in various fields is chosen for disc of an automotive for yielding good results.**

***Keywords* — Catia: Disc design, ansys: steady state temperature analysis.**

I. INTRODUCTION

The Disc-style brakes development and use began in England in the 1890's. The first caliper-type automobile disc brake Was patented by Frederick William lanchester Disc brakes were most popular on sports cars when they were first introduced, since these vehicles are more demanding about brake performance. Discs have now become the more common form in most passenger vehicles, although particularly in light weight vehicles. As the front brakes perform most of the braking effort, this can be a reasonable compromise. The weight and power of the vehicle determines the need of ventilated holes on the disc, because when weight and power of the vehicle increases the heat production also increases. So that shape and size of the disc brake also changes.

In our study, to know the observable behavior of these materials, which are used for making disc for two wheeler model commonly there are many shapes like circular, non circular. Among which we have chosen non circular shape because of high mean temperature distribution and good heat dissipation. It is concentrated firstly on temperature distribution under the air temperature of 40^{o}c and secondly the comparison of the materials mentioned above with their capability to withstand which experiences the temperature around 19^{o}c to 40^{o}c through a compressible air medium. Based on the shape the air intensity may be directed around the disc by balancing the force with whole body, when the air intensity exerts on the disc, it is subjected to some stresses, strains also along with the deformation. When simulated with ANSYS in the static environment.

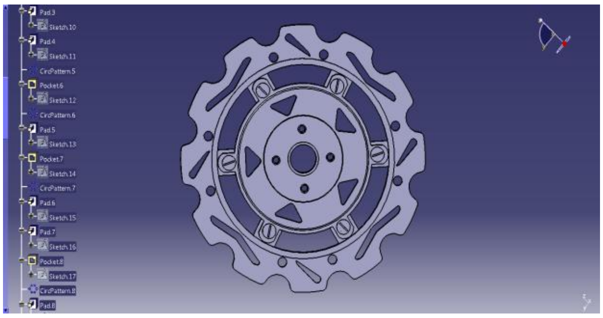


Figure1: The final design which designed by using CATIAV5

II. MODELING AND ANALYSIS

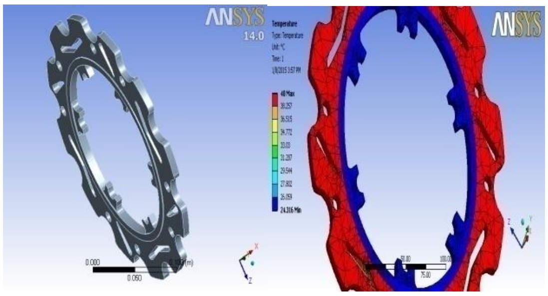
First we took CATIAv5 software (sketcher, part design) initially two base circles are drawn, which are similar using PAD options, making it circle at center of disc modeling by using 3D intersection. Then mark wings at four sides of circles, again PADING and then the circular pattern we filled with ventilated wholes shape and finally it is obtained full pledged model which is ready for detect by the ANSYSv11.then it is imported to the ANSYS workbench to do analysis of the model. By using ANSYSv11, we can compute the response of a steady state computing the response of a steady state system involves analyzing a wide range temperatures and the simulation must take into account on interactions between the various parts of product, its working environment and the effects of other forces such as electromagnetic and fluid Dynamics Structural mechanics solutions from ANSYS set the industry standard in engineering. Simulate every structural aspect including model analysis, time-varying, and load response. This incorporates Linear and non-linear transient dynamic analysis and spectrum analysis for random vibrations. Using the ANSYS results end to- end solution. Our model once imported into the ANSYS we are choosing the materials like Aluminum alloy, gray cast iron and titanium alloy by maintaining disc shape and size as constant initially, after choosing various materials, we generated mesh for all materials and then allowing for simulation.

In the simulation it consist steady state analysis in which it is specified the spot at which the air temperature 40^0c is supposed to be apply, and the behavior of various materials under this temperature is depicted through the print review of simulation.

III. MESH GENERATION

Meshing is done for converting a continuous object into finite no. of parts known as elements. Meshing of the brake disc and pad has been done using Comsol Metaphysics. The element used for meshing is of tetrahedral shape. The below figures are represent the temperature distribution during in analysis of steady state condition.

Before & after meshing of disc



Materials used

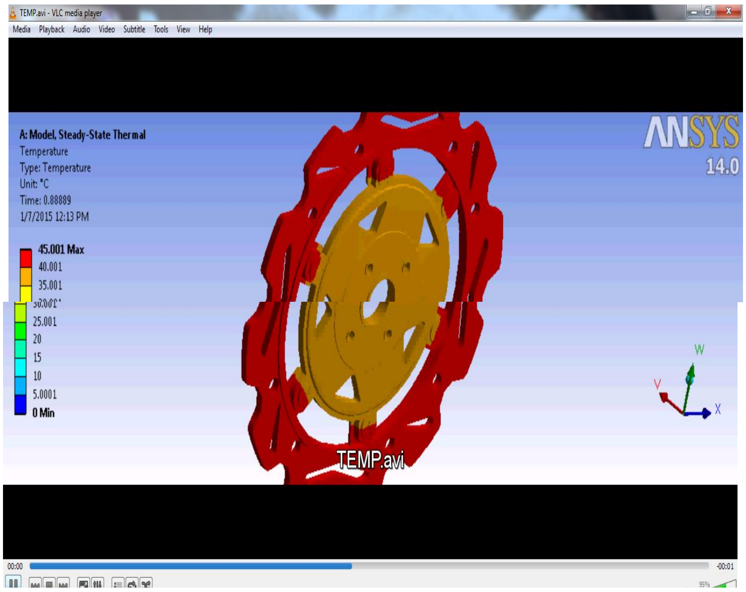
Gray cast iron-Cast iron usually refers to grey cast iron, Iron accounts for more than 95%, The amount of carbon in cast iron is the range 2.1-4%, Cast irons contain appreciable amounts of silicon, normally 1-3%

Titanium alloy-Titanium alloys and their composites have the potential to reduce weight of the brake rotor disc component which is about 37% less than a conventional cast iron with the same dimensions and offering good high temperature strength and better resistance to corrosion.

Aluminum alloy-Aluminum alloy based metal matrix composites (MMCs) with ceramic particulate reinforcement have shown great promise for brake rotor applications. These materials having a lower density and higher thermal conductivity as compared to the conventionally used gray cast irons are expected to result in weight reduction of up to 50-60% in brake systems. The friction properties of the AMC brake disc are thus remarkable poorer than those of conventional brake disc. Based on the properties, potential candidate materials for automotive brake disc were selected.

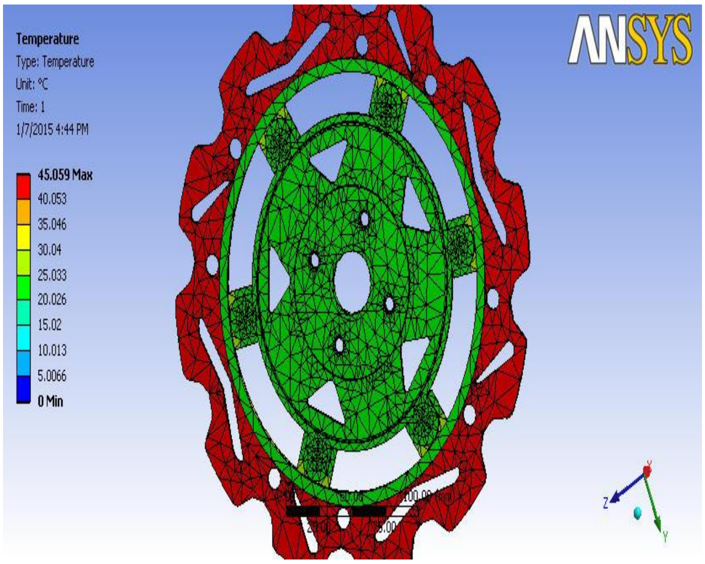
Table 4.1 PROPERTIES OF MATERIALS USED

PROPERTIES	MATERIAL 1	MATERIAL 2	MATERIAL 3
DENSITY, ρ	7100 Kg/m³	2765.2 Kg/m³	2820.6 Kg/m³
YOUNGS MODULUS,E	125 GPa	98.5 GPa	113.76 GPa
THERMAL CONDUCTIVITY, k	54 W/m.K	181.65 W/m.K	147.95 W/m.K
SPECIFIC HEAT, C_p	586 J/Kg.K	836.8 J/Kg.K	828.43 J/Kg.K
POSSION'S RATIO, υ	0.25	0.33	0.35
COEFFICIENT OF EXPANSION, α	$8.1*10^{-6}/^0K$	$17.5*10^{-6}/^0K$	$16.9*10^{-6}/^0K$



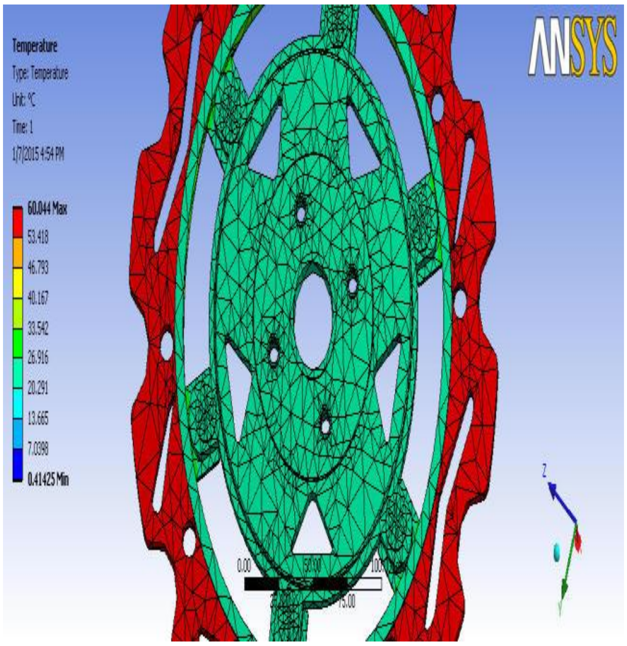
Structural	
Young's Modulus	1.1e+005 MPa
Poisson's Ratio	0.28
Density	7.2e-006 kg/mm³
Thermal Expansion	1.1e-005 1/°C
Tensile Yield Strength	0. MPa
Compressive Yield Strength	0. MPa
Tensile Ultimate Strength	240. MPa
Compressive Ultimate Strength	820. MPa
Thermal	
Thermal Conductivity	5.2e-002 W/mm·°C
Specific Heat	447. J/kg·°C
Electromagnetics	
Relative Permeability	10000
Resistivity	9.6e-005 Ohm·mm

Figure 2: Ansys results temperature distribution of gray cast iron disc under given conditions



Structural	
Young's Modulus	96000 MPa
Poisson's Ratio	0.36
Density	4.62e-006 kg/mm³
Thermal Expansion	9.4e-006 1/°C
Tensile Yield Strength	930. MPa
Compressive Yield Strength	930. MPa
Tensile Ultimate Strength	1070. MPa
Compressive Ultimate Strength	0. MPa
Thermal	
Thermal Conductivity	2.19e-002 W/mm·°C
Specific Heat	522. J/kg·°C
Electromagnetic	
Relative Permeability	10000
Resistivity	1.7e-003 Ohm·mm

Figure 3: Ansys results temperature distribution of titanium alloy disc under given conditions



Structural	
Young's Modulus	96000 MPa
Poisson's Ratio	0.36
Density	4.62e-006 kg/mm³
Thermal Expansion	9.4e-006 1/°C
Tensile Yield Strength	930. MPa
Compressive Yield Strength	930. MPa
Tensile Ultimate Strength	1070. MPa
Compressive Ultimate Strength	0. MPa
Thermal	
Thermal Conductivity	2.19e-002 W/mm·°C
Specific Heat	522. J/kg·°C
Electromagnetic	
Relative Permeability	10000
Resistivity	1.7e-003 Ohm·mm

Figure 4: Ansys results temperature distribution of aluminum alloy disc under given conditions

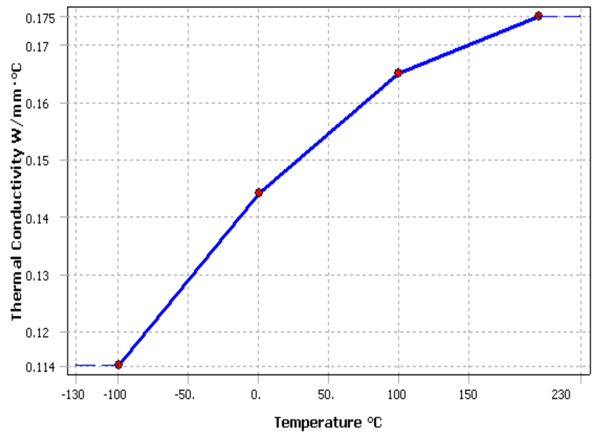
IV. RESULTS

The following figures from (Figure 2 to Figure 4), explaining about the testing phase with temperature of 40°c at a steady state condition by using ANSYSv11 software package, where the model of disc of bike which is made by the different materials like aluminum alloy, gray cast iron and titanium alloy. The left hand side of each figure represents the temperature changes from maximum range to minimum from extreme edge of disc to contour towards back side of disc respectively. Also the temperature distribution is clearly mentioned from max to min by different colors on the disc, it gives a lucid understanding about the distribution which occurs at various spots at various magnitudes, then it bring proper idea to compare the materials under constant atmosphere temperature and maximum temperature in the static position of the disc in the ansysv11. And right hand side of each figure represents the material essential properties of each material which are very different from one material to another. Aluminum is widely available and cheapest material. From thermal analysis, by observing the thermal gradient for both the materials, the value is more for aluminum alloy.

.The disc when it is tested in the steady state condition under a given air temperature 40oc by the ANSYSv11 software, it is subjected to the various ranges of distribution. The maximum value and minimum value as per above mentioned three materials listed in the following table. From the table we can make analysis of the behavior of the materials. From the Graph it is understand that the aluminum alloy is subjected to more heat dissipation and titanium alloy is subjected to next. Which are much intended to corrosion compared to other materials of aluminum and titanium alloys. But strength point of view gray cast iron is strong (in terms of deformation) than the aluminum and titanium alloys Compared to other properties, which are mentioned right hand side of the figures 2, 3 and 4, the titanium alloy is having moderate features among the other two of the materials

TABLE I.

Results	**The temperature flow in various materials**		
	Maximum	***Minimum Occurs On***	***Maximum Occurs On***
Gray cast iron	45.001 °C	Part 2	Part 1
Aluminum alloy	60.044 °C	Part 2	Part 1
Titanium alloy	45.059 °C	Part 2	Part 1



CONCLUSION

In the present study, the disc is prepared by the CATIA and ANSYS software. We have performed Thermal analysis using aluminum alloy, titanium alloy and gray cast iron on the disc brake And analysis made to know the distribution of the temperature in the steady state environment. It says that the aluminum alloy is subjected to more heat dissipation and titanium alloy is subjected to next Along with .the thermal gradient for both the materials, the value is more for aluminum alloy. The rate of temperature change for brake surface using aluminum alloy is more than that of using gray cast iron and titanium alloy. From thermal analysis, by observing Aluminum is widely available and cheapest material. It is the good alternative of gray cast iron and also strength is high when we add composite materials to aluminum. Aluminum alloy having better properties which is now days most popularly used in various fields are chosen for disc of a bike for yielding good results. The present study can provide a useful design tool and improve the brake performance of disk brake system.

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