Structural and Thermal Analysis of Disc Plate

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Abstract--- *Braking is a process which converts the kinetic energy of the vehicle into mechanical energy which must be dissipated in the form of heat. The disc brake is a device for de-accelerating or stopping the rotation of a wheel. A brake disc (or rotor) usually made of cast iron or ceramic composites, is connected to the wheel and/or the axle. 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 to stop the wheel. The disc brake is a device used for slowing or stopping the rotation of the vehicle. Number of times using the brake for vehicle leads to heat generation during braking event, such that disc brake undergoes breakage due to high Temperature. Disc brake model is done by Solidworks and analysis is done by using ANSYS workbench. The main purpose of this project is to study the Thermal analysis of the Materials for the Rene 41, Elgiloy and 6063 T5 Alloy. A comparison between the four materials for the Thermal values and material properties obtained from the Thermal analysis low thermal gradient material is preferred. The results have been compared for better justification. Thus, the results provide better understanding on the thermal characteristic of disc brake rotor and assist the automotive industry in developing optimum and effective disc brake.*

Keywords--- *Ansys, Solidworks, Rene41, Elgiloy, 6063t5 Alloy.*

I. INTRODUCTION

In today's growing automotive market, the competition for better performance vehicle is growing enormously. The disc brake is a device used for slowing or stopping the rotation of the wheel. A brake is usually made of cast iron or ceramic composites include carbon, aluminum, Kevlar and silica which is connected to the wheel and axle, to stop the vehicle. A friction material produced in the form of brake pads is forced mechanically, hydraulically, pneumatically and electromagnetically against the both side of the disc. This friction causes the disc and attached wheel to slow or to stop the vehicle. The methods used in the vehicle are regenerative braking system and friction braking system. A friction brake generates the frictional force in two or more surfaces rub against to each other, to reduce the movement. Based on the design configurations vehicle friction brakes are grouped into disc brakes and drum brakes. Our project is about disc brakes modeling and analysis.

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Repetitive braking of a vehicle generates large amount of heat. This heat has to be dissipated for better performance of brake. Braking performance largely affected by the temperature rise in the brake components. High temperature may cause thermal cracks, brake fade, wear and reduction in coefficient of friction.

During braking, the kinetic and potential energies of a moving vehicle get converted into thermal energy through friction in the brakes. The heat generated between the brake pad & disc has to be dissipated by passing air over them. This heat transfer takes place by conduction, convection and somewhat by radiation. To achieve proper cooling of the disc and the pad by convection, study of the heat transport phenomenon between disc, pad and the air medium is necessary. Then it is important to analyze the thermal performance of the disc brake system to predict the increase in temperature during braking. Convective heat transfer model has been developed to analyze the cooling performance. Brake discs are provided with cuts to increase the area coming in contact with air and improve heat transfer from disc. In this paper two different cut patterns of brake disc are studied for heat transfer rate. Heat transfer rate increases with number of cuts in the disc. This is because large area is exposed to air which makes more heat transfer through conduction and convection. But increase in number and size of cuts decreases the strength of disc.

II. PROBLEM STATEMENT

- Discs are made up mainly gray cast iron, so discs are damaged in one of three ways: scarring, cracking, warping or excessive rusting. Service shops will sometimes respond to any disc problem by changing out the discs entirely.
- This is done mainly where the cost of a new disc may actually beresurface the original disc.
- Mechanically this is unnecessary unless the discs have reached manufacturer's minimum recommended thickness, which would make it unsafe to use them, or vane rusting severe (ventilated discs only).

III. METHODOLOGY

- Structural and Thermal analysis of Disc plate is designed by using SOLIDWORKS 2018 modelling software and the analysis carried out by ANSYS WORKBENCH 16.0 .
- After completing the design part that could be saved by the iges format and directly imported to the ansys work bench.
- Here we have analysis the heat dissipation, heat flux and various deformation of choosen material.

IV. MATERIAL PROPERTIES

Material Properties	Elgiloy	6063 T5 Alloy	Rene 41	Grey Cast Iron
Thermal conductivity(W/m K)	12.5	209	25	52
Density , ρ (kg/m^3)	8300	2700	8248.6	7200
Specific heat , c (J/Kg C)	431.24	900	460	447
Elastic modulus, E (GPa)	1900	70	2000	1100
Coefficient of friction, μ	0.5	0.5	0.5	0.5
Film co-efficient h(W/K-m^2)	230	230	230	230
Angular velocity,(rad /s)	50	50	50	50
Braking Time Sec	5	5	5	5
Hydraulic pressure, P (M pa)	1	1	1	1

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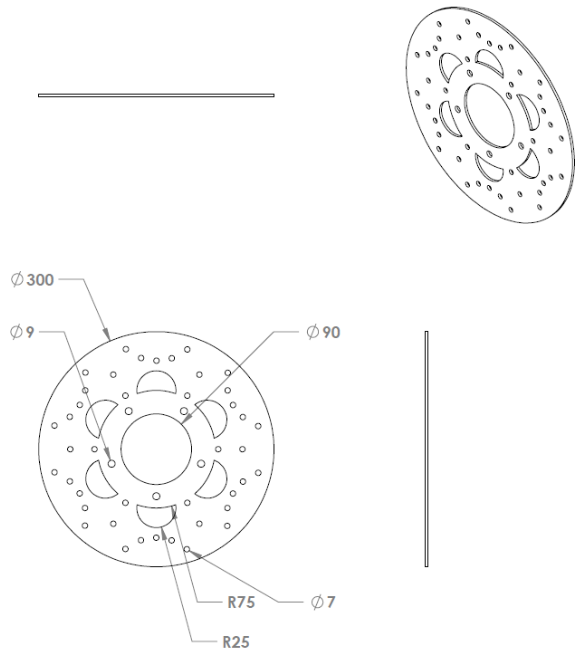
V. DESIGN MODEL



From the above design model we can conclude that design model 5 is both cost efficient and takes less time for manufacturing. Now, we will see the different variants of the design model 5 by varying its hole diameter and angle between those holes.

VI. RESULT AND DISCUSSION

No. of Holes Pattern

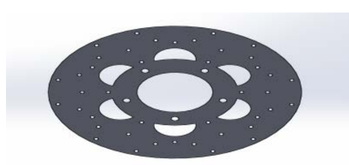


Fig.(a)

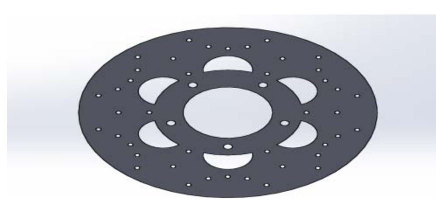


Fig.(b)

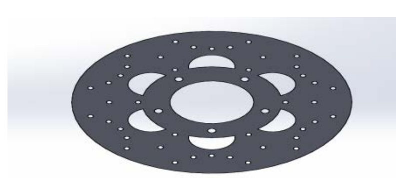


Fig.(c)

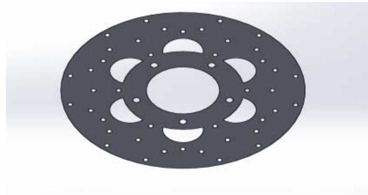


Fig.(d)

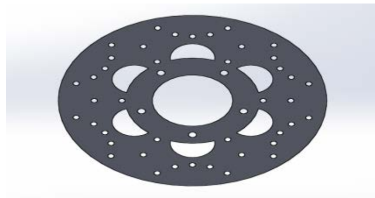


Fig.(e)

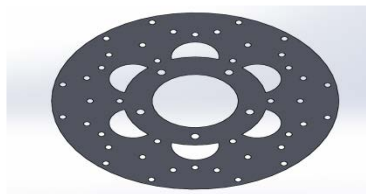


Fig.(f)

Model (a): Small Hole Diameter = 5mm, Angle between Holes = 30

Model (b): Small Hole Diameter = 5mm, Angle between Holes = 35

Model (c): Small Hole Diameter = 6mm, Angle between Holes = 30

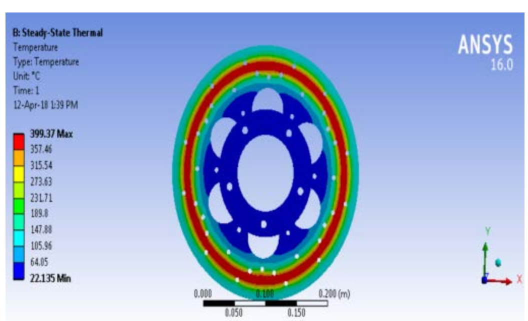
Model (d): Small Hole Diameter = 6mm, Angle between Holes = 35

Model (e): Small Hole Diameter = 7mm, Angle between Holes = 30

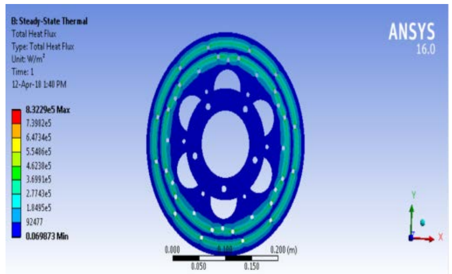
Model (f): Small Hole Diameter = 7mm, Angle between Holes = 3

VII. MATERIAL ANALYSIS

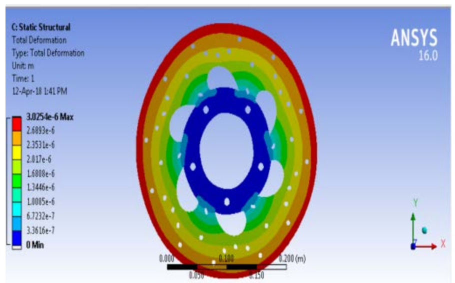
Elgiloy



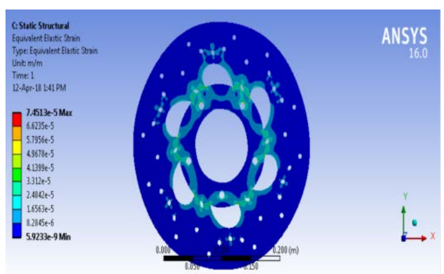
Temperature



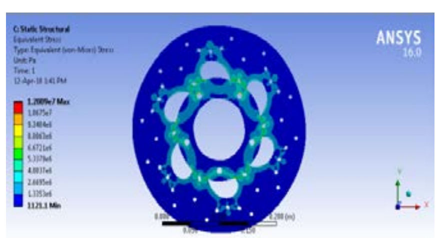
Total heat flux



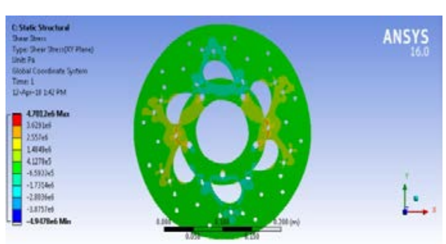
Total deformation



Equivalent elastic strain



Equivalent stress



Shear stress

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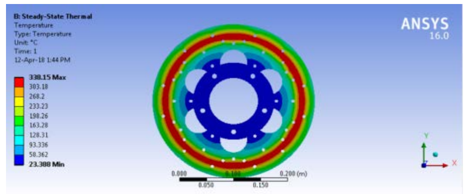
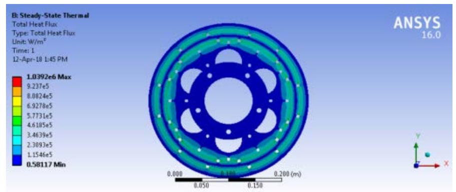
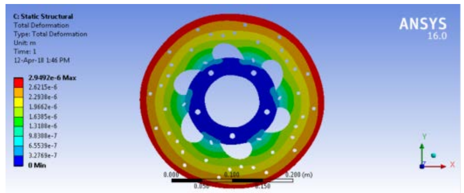
Rene 41



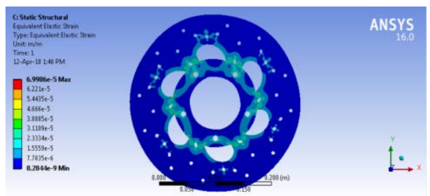
Temperature



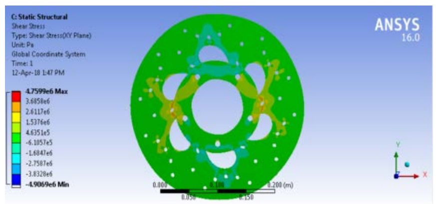
Total heat flux



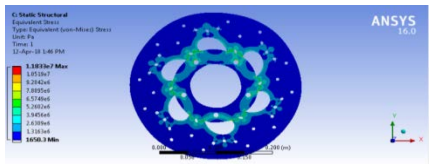
Total deformation



Equivalent elastic strain



Equivalent stress



Shear stress

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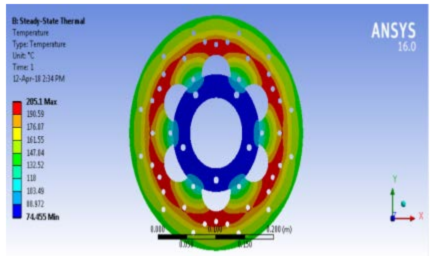
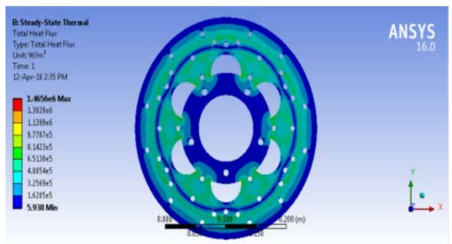
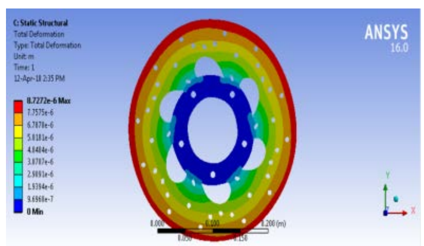
Aluminum 6063 T5 Alloy



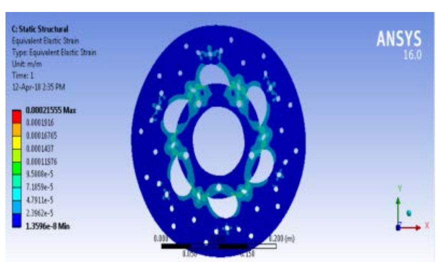
Temperature



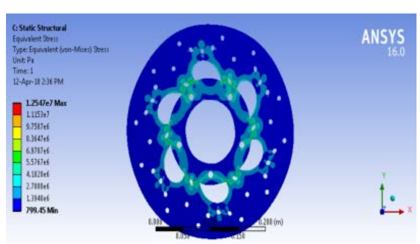
Total heat flux



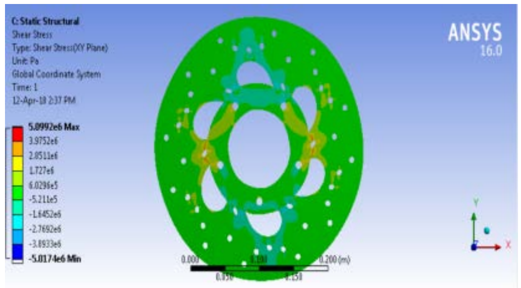
Total deformation



Equivalent elastic strain



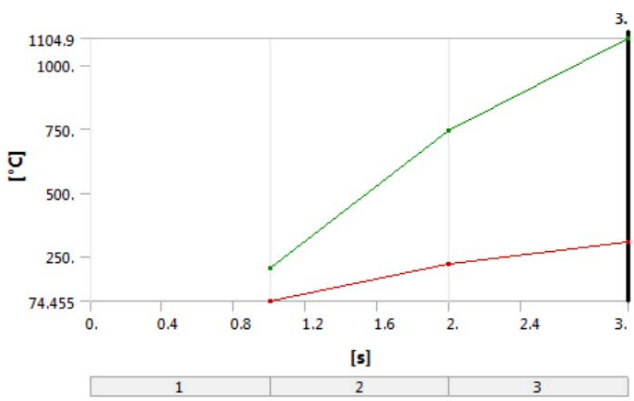
Equivalent stress



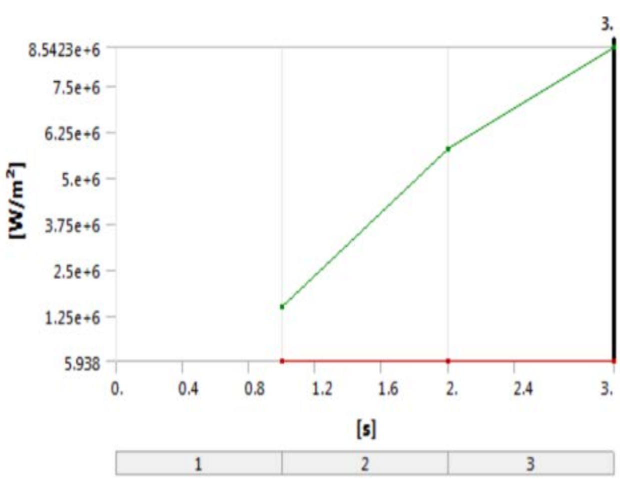
Shear stress

Property	Elgiloy	Rene 41	6063 T5 Alloy
Temperature (C)	399.37	338.15	205.1
Total Heat Flux (W/m^2)	8.3229 e^5	1.0392 e^6	1.4656 e^6
Total Deformation (m)	3.0254 e^{-6}	2.9492 e^{-6}	8.7272 e^{-6}
Equivalent Elastic Strain	7.4513 e^{-5}	6.9986 e-5	0.00021555
Equivalent Stress (Pa)	1.2009 e^7	1.1833 e^7	1.2547 e^7
Shear Stress	4.7012 e^6	4.7599 e^6	5.0992 e^6

1.Time vs Temperature



2. Time vs Total Heat Flux



VIII. CONCLUSION

In this project we analysed that disc plate result is good for new material , we compare the different results of temperature , total deformation , heat dissipation and stress obtained .We also a create a meshing for decreasing error and negative values in Choosen material. It shows RENE 41 , ELGILOY will give reduction in heat rate , its have minimum values than other materials we analysed. Disc plate design will safe according to strength , stability and rigidity criteria.

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