DESIGN AND ANALYSIS OF CLUTCH LINER USING POLYMER FIBRE

Priyanka B[1], Koruth Sam K[2], Sridhar. K[3], Santhanakrishnan. S[4]

[1]Mechanical Engineering Department, Meenakshi Sundararajan Engineering College
[2]Mechanical Engineering Department, Meenakshi Sundararajan Engineering College
[3]Assistant Professor, Department of Mechanical Engineering, Meenakshi Sundararajan Engineering College, Tamil Nadu, *India*
[4]Associate Professor, Department of Mechanical Engineering, Meenakshi Sundararajan Engineering College, Tamil Nadu, *India*

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Abstract - *The objective of the project is to Design and Analysis of Clutch Lining using different materials. A Clutch is a machine member used to connect the driving shaft to a driven shaft, so that the driven shaft may be started or stopped at will, without stopping the driving shaft. A common and well known application for the clutch is in automotive vehicles where it is used to connect the engine and the gearbox. Here the clutch enables to crank and start the engine disengaging the transmission and change the gear to alter the torque on the wheel. Various materials have been used for the disc-friction facings, including asbestos in the past. Modern clutches typically use a compound organic resin with copper wire facing or a ceramic material. In this project we use Kevlar, Silicon Carbide, Polymer fibre, material for clutch liner.*

Key Words: Clutch lining, transmission system, clutch liner materials, polymer fibre.

1. INTRODUCTION

The clutch is a very important machine element which plays a main role in the transmission of power from one component (driving part of machinery) to another (driven part of machinery). It is usually placed between the driving motor and the input shaft to a machine, permitting the engine to be started in an unloaded state. It is commonly used in automotive vehicles where it is used to connect the engine and the gearbox through an interruptible connection between two rotating shafts. A commonly known application of clutch is in automotive vehicles where it is used to create engagement and disengagement between engine and the gear box for smooth performance of vehicle.

Here the clutch enables to crank and start the engine disengaging the transmission and change the gear to alter the torque on the wheels. Clutches are also used extensively in production machinery of all types. Clutches allow a high inertia load to be stated with a small power. The main agenda of this project is to analyze the clutch liner and the specification of the material that may be used for making the clutch liner.

2. THEORETICAL ANALYSIS

2.1 Raw material used

KEVLAR

Kevlar is an organic fiber in the aromatic polyamide family. The unique properties and distinct chemical composition of wholly aromatic polyamides (aramids) distinguish them - and especially Kevlar - from other commercial, man-made fibers.

Kevlar has a unique combination of high strength, high modulus, toughness and thermal stability. It was developed for demanding industrial and advanced-technology applications. Currently, many types of Kevlar are produced to meet a broad range of end uses.

BORON CARBIDE

Boron carbide (chemical formula approximately B_4C) is an extremely hard boron–carbon ceramic, and ionic material used in tank armor, bulletproof vests, engine sabotage powders, as well as numerous industrial applications. With a Vickers Hardness of >30 MPa, it is one of the hardest known materials, behind cubic boron nitride and diamond.

Boron carbide was discovered in 19th century as a by-product of reactions involving metal borides, however, its chemical formula was unknown. It was not until the 1930s that the chemical composition was estimated as B_4C. There remained, however, controversy as to whether or not the material had this exact 4:1 stoichiometry, as in practice the material is always slightly carbon-deficient with regard to this formula, and X-ray crystallography shows that its structure is highly complex, with a mixture of C-B-C chains and B_{12} icosahedra. These features argued against a very simple exact B_4C empirical formula. Because of the B_{12}structural unit, the chemical formula of "ideal" boron carbide is often written not as B_4C, but as $B_{12}C_3$, and the carbon deficiency of boron carbide described in terms of a combination of the $B_{12}C_3$ and $B_{12}CBC$ units.

The ability of boron carbide to absorb neutrons without forming long-lived radionuclides makes it attractive as an absorbent for neutron radiation arising in nuclear power plants and from anti-personnel neutron bombs. Nuclear applications of boron carbide include shielding, control rod and shut down pellets. Within control rods, boron carbide is often powdered, to increase its surface area.

POLY PROPYLENE

It is a type of polymer thermally stable polymer with an excellent resistance to stress, cracking and chemical reaction, it is much stronger it is thinner, contain less polymer and cost less than conventional polyethylene products.

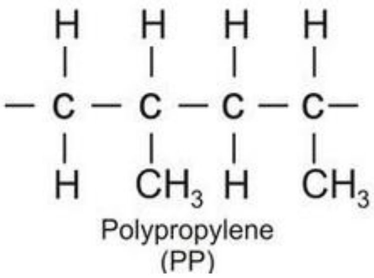


Fig -1: Structure of poly propylene

3. DESIGN

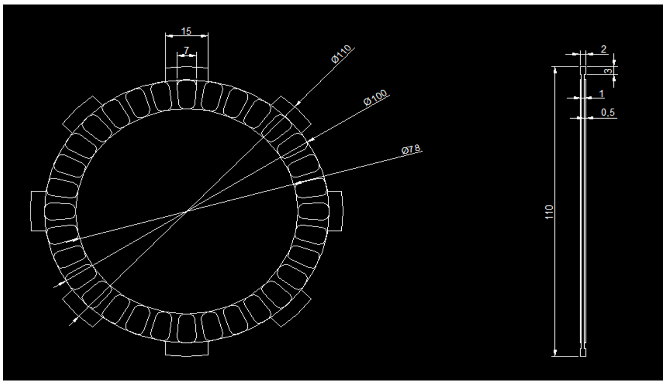


Fig -2: 2D design of clutch plate using AutoCAD 2010

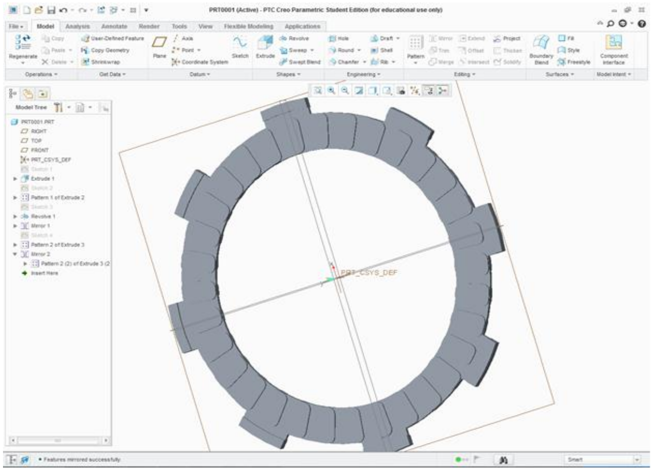


Fig -3: 3D design of clutch plate using Creo2.0

4. SPECIFICATION AND CALCULATIONS

4. 1 Specification of clutch (Discover 100cc bike)

Torque = 120 Nm at speed N = 750

r_1 = 55 mm

r_2 = 39 mm

n = no of pairs of contact surfaces.

$n = n_1 = n_2 - 1$

Where n_1 and n_2 are no of disc on driving and driven shaft.

$n_1 = 5$

$n_2 = 4$

$n = 5 + 4 - 1$

$n = 8$

R = mean radius of friction surface

M = coefficient of friction

T = transmitting torque

W = total operating force

P = intensity of pressure of radius r (N/mm^2)

Calculating operating force and operating average pressure by using uniform wear theory as follows:

Kevlar friction material.

$R = (r_1 - r_2) / 2$

$= (55 - 39) / 2$

= 47 mm

= 0.047 m

Required operating force

T = n x m x w x R

120 = 8 x 0.22 x w x 47

W =120/ (8*0.22*0.047)

W = 120 / 0.08272

= 1450.67 N

Average operating pressure

$W = (2 \times \pi \times P \times r_2) \times (r_1 - r_2)$

$1450.67 = (2 \times \pi \times P \times 39) \times (55 - 39)$

$P = 1450.67 / (2*\pi*39)*(55-39)$

$= 0.37$ Mpa

4.2 Software used

- AutoCAD 2010
- Creo2.0
- Ansys13

5. RESULT AND ANALYSIS

5.1 Kevlar

Static structural analysis

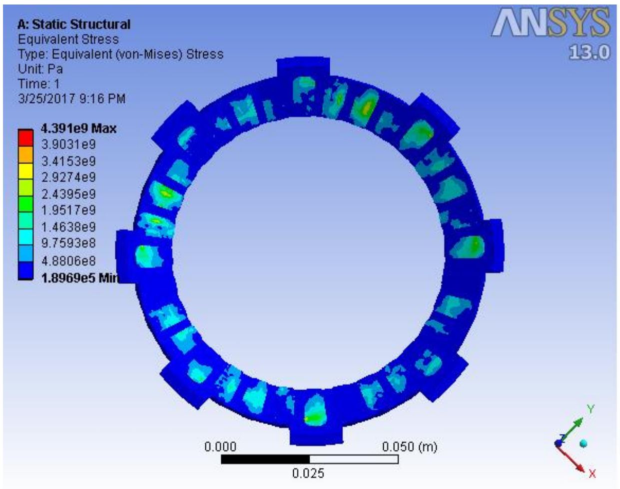


Fig -4: Stress in Kevlar

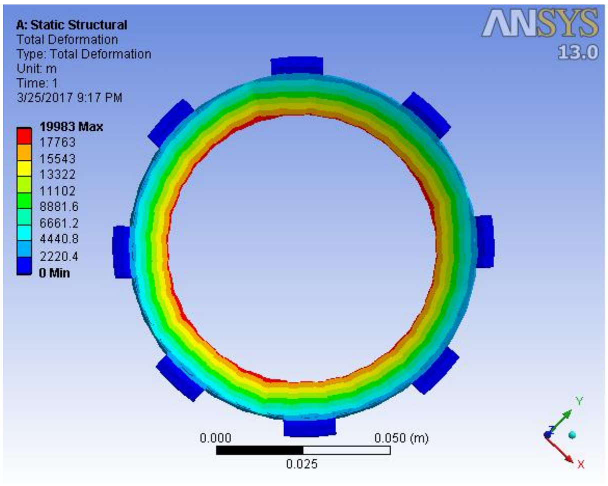
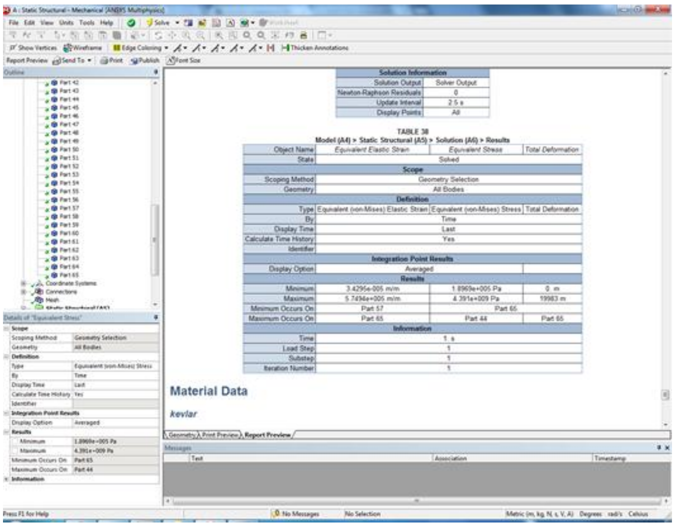


Fig -5: Deformation in Kevlar



Solution Information	
Solution Output	Solver Output
Newton-Raphson Residuals	0
Update Interval	2.5 s
Display Points	All

TABLE 38
Model (A4) > Static Structural (A5) > Solution (A6) > Results

Object Name	*Equivalent Elastic Strain*	*Equivalent Stress*	*Total Deformation*
State	Solved		
Scope			
Scoping Method	Geometry Selection		
Geometry	All Bodies		
Definition			
Type	Equivalent (von-Mises) Elastic Strain	Equivalent (von-Mises) Stress	Total Deformation
By	Time		
Display Time	Last		
Calculate Time History	Yes		
Identifier			
Integration Point Results			
Display Option	Averaged		
Results			
Minimum	3.4295e-005 m/m	1.8969e+005 Pa	0. m
Maximum	5.7494e+005 m/m	4.391e+009 Pa	19983 m
Minimum Occurs On	Part 57	Part 65	
Maximum Occurs On	Part 65	Part 44	Part 65
Information			
Time	1. s		
Load Step	1		
Substep	1		
Iteration Number	1		

Material Data

kevlar

Fig -6: Results for Kevlar Structural analysis

Thermal Analysis

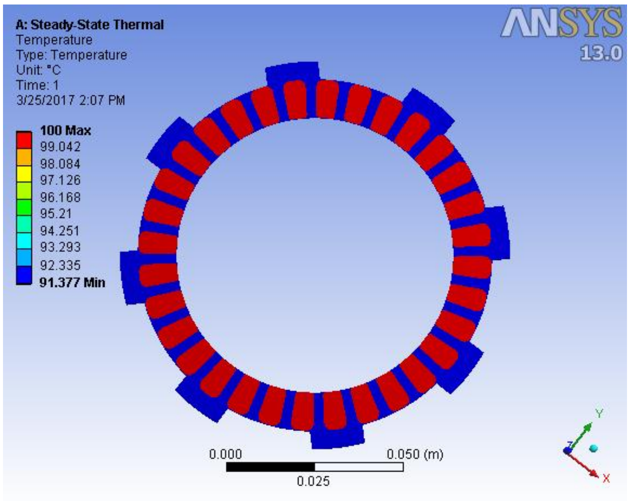


Fig -7: Temperature of Kevlar

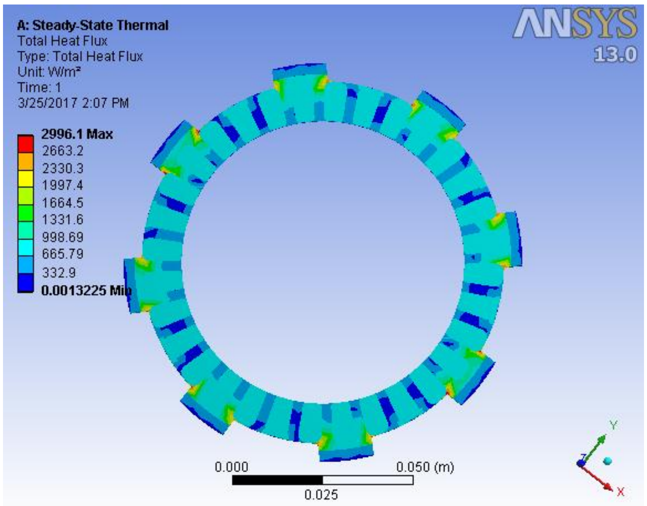
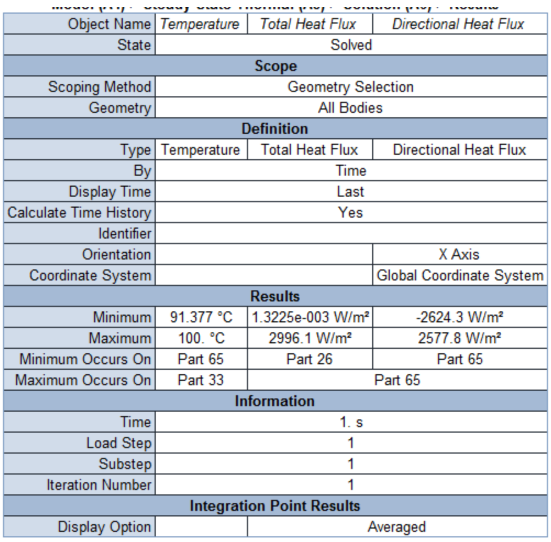


Fig -8: Kevlar heat flux



Object Name	*Temperature*	*Total Heat Flux*	*Directional Heat Flux*
State	Solved		
Scope			
Scoping Method	Geometry Selection		
Geometry	All Bodies		
Definition			
Type	Temperature	Total Heat Flux	Directional Heat Flux
By	Time		
Display Time	Last		
Calculate Time History	Yes		
Identifier			
Orientation			X Axis
Coordinate System			Global Coordinate System
Results			
Minimum	91.377 °C	1.3225e-003 W/m²	-2624.3 W/m²
Maximum	100. °C	2996.1 W/m²	2577.8 W/m²
Minimum Occurs On	Part 65	Part 26	Part 65
Maximum Occurs On	Part 33	Part 65	
Information			
Time	1. s		
Load Step	1		
Substep	1		
Iteration Number	1		
Integration Point Results			
Display Option		Averaged	

Fig -9: Results for Kevlar thermal analysis

5.2 Boron Carbide

Static structural analysis

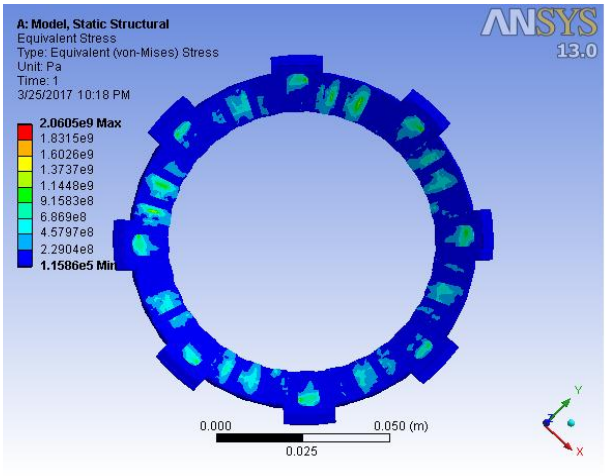


Fig -10: Stress in Boron carbide

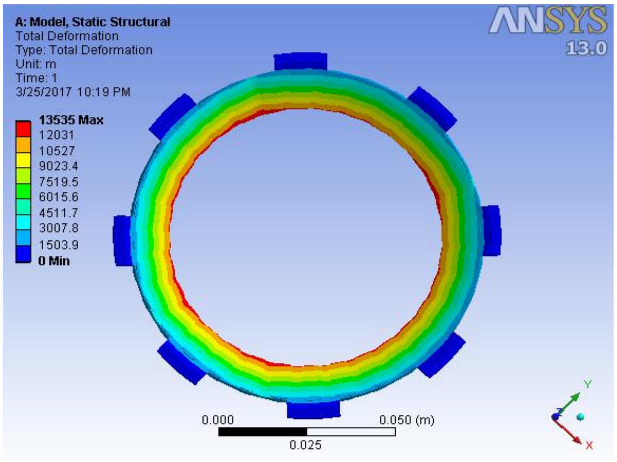
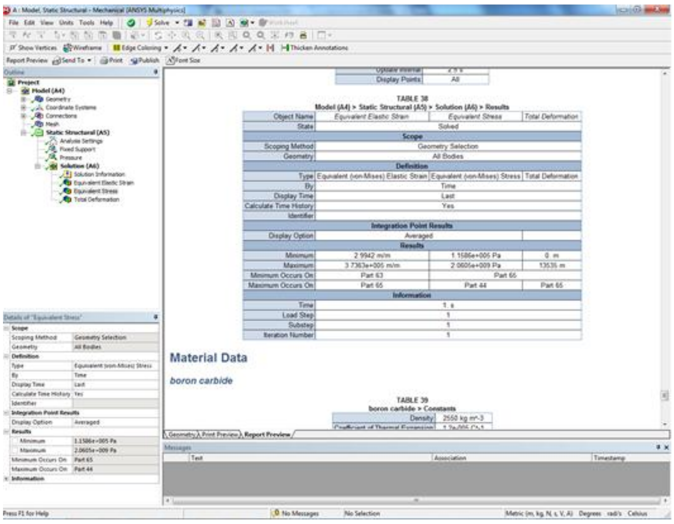


Fig -11: Deformation in Boron carbide



Display Points	All

TABLE 38
Model (A4) > Static Structural (A5) > Solution (A6) > Results

Object Name	*Equivalent Elastic Strain*	*Equivalent Stress*	*Total Deformation*
State	Solved		
Scope			
Scoping Method	Geometry Selection		
Geometry	All Bodies		
Definition			
Type	Equivalent (von-Mises) Elastic Strain	Equivalent (von-Mises) Stress	Total Deformation
By	Time		
Display Time	Last		
Calculate Time History	Yes		
Identifier			
Integration Point Results			
Display Option	Averaged		
Results			
Minimum	2.9942 m/m	1.1586e+005 Pa	0. m
Maximum	3.7363e+005 m/m	2.0605e+009 Pa	13535 m
Minimum Occurs On	Part 63	Part 65	
Maximum Occurs On	Part 65	Part 44	Part 65
Information			
Time	1. s		
Load Step	1		
Substep	1		
Iteration Number	1		

Material Data

boron carbide

TABLE 39
boron carbide > Constants

Density	2550 kg m^-3

Fig -12: Results for Boron carbide structural analysis

Thermal Analysis

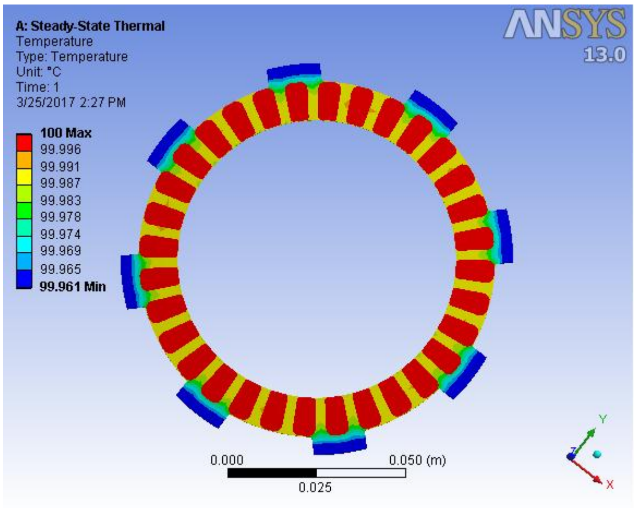


Fig -13: Temperature of Boron carbide

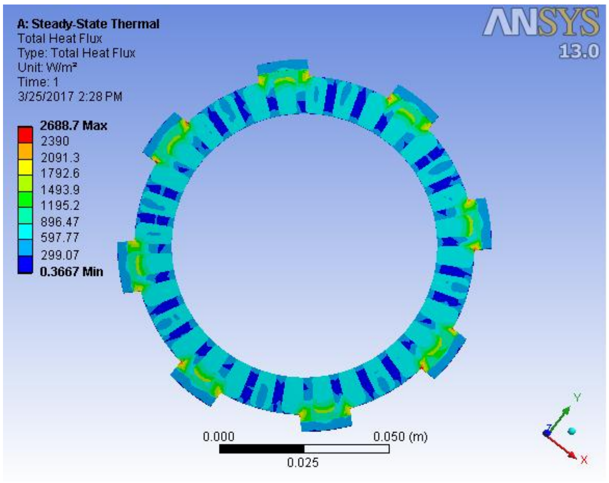
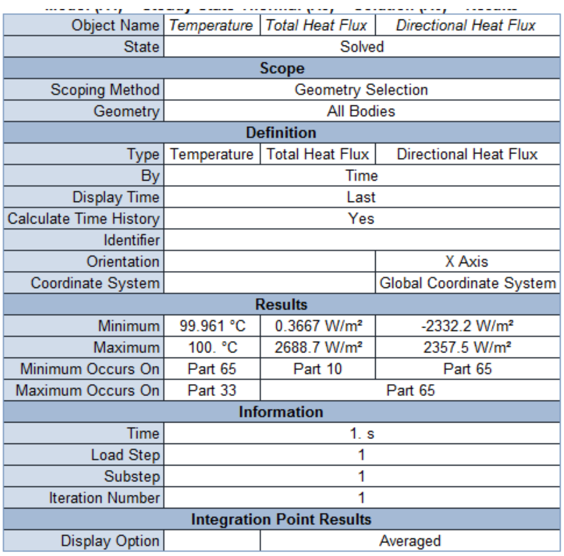


Fig -14: Boron carbide heat flux



Object Name	*Temperature*	*Total Heat Flux*	*Directional Heat Flux*
State	Solved		
Scope			
Scoping Method	Geometry Selection		
Geometry	All Bodies		
Definition			
Type	Temperature	Total Heat Flux	Directional Heat Flux
By	Time		
Display Time	Last		
Calculate Time History	Yes		
Identifier			
Orientation			X Axis
Coordinate System			Global Coordinate System
Results			
Minimum	99.961 °C	0.3667 W/m^2	-2332.2 W/m^2
Maximum	100. °C	2688.7 W/m^2	2357.5 W/m^2
Minimum Occurs On	Part 65	Part 10	Part 65
Maximum Occurs On	Part 33	Part 65	
Information			
Time	1. s		
Load Step	1		
Substep	1		
Iteration Number	1		
Integration Point Results			
Display Option		Averaged	

Fig -15: Results for boron carbide thermal analysis

5.3 Polypropylene

Static structural analysis

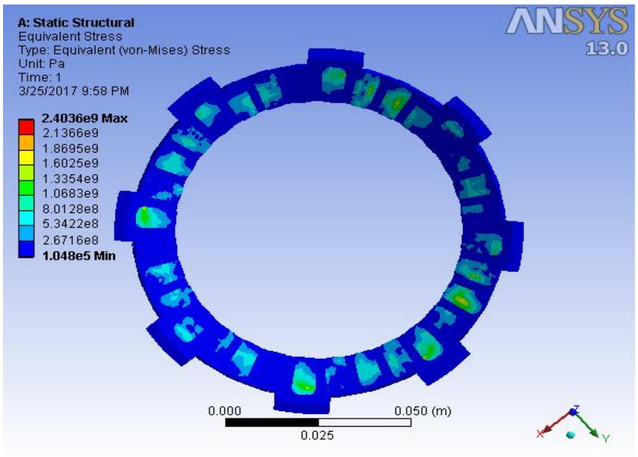


Fig -16: Stress in Polypropylene

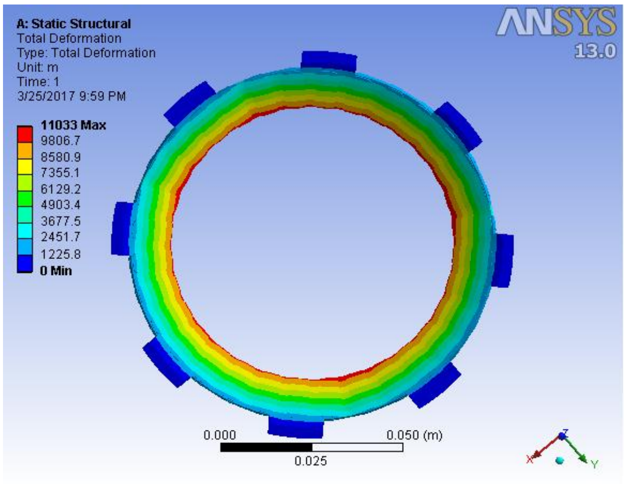


Fig -17: Deformation in Polypropylene

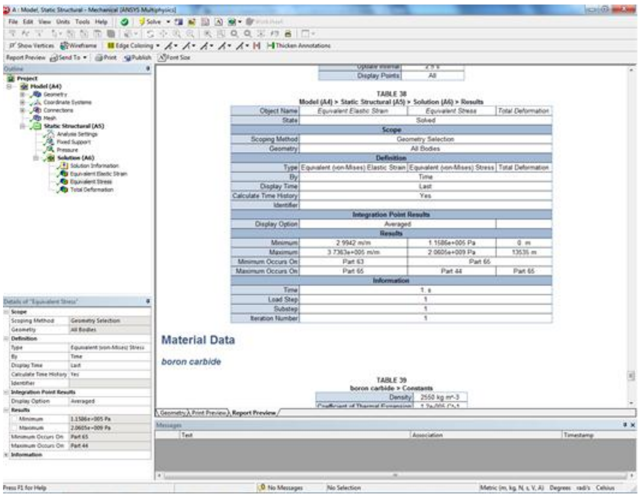


TABLE 38
Model (A4) > Static Structural (A5) > Solution (A6) > Results

Object Name	*Equivalent Elastic Strain*	*Equivalent Stress*	*Total Deformation*
State	Solved		
Scope			
Scoping Method	Geometry Selection		
Geometry	All Bodies		
Definition			
Type	Equivalent (von-Mises) Elastic Strain	Equivalent (von-Mises) Stress	Total Deformation
By	Time		
Display Time	Last		
Calculate Time History	Yes		
Identifier			
Integration Point Results			
Display Option	Averaged		
Results			
Minimum	2.9942 m/m	1.1586e+005 Pa	0. m
Maximum	3.7363e+005 m/m	2.0606e+009 Pa	13535 m
Minimum Occurs On	Part 63	Part 65	
Maximum Occurs On	Part 65	Part 44	Part 65
Information			
Time	1. s		
Load Step	1		
Substep	1		
Iteration Number	1		

Material Data

boron carbide

TABLE 39
boron carbide > Constants

Density	2550 kg m^-3

Fig -18: Results for Polypropylene structural analysis

Thermal Analysis

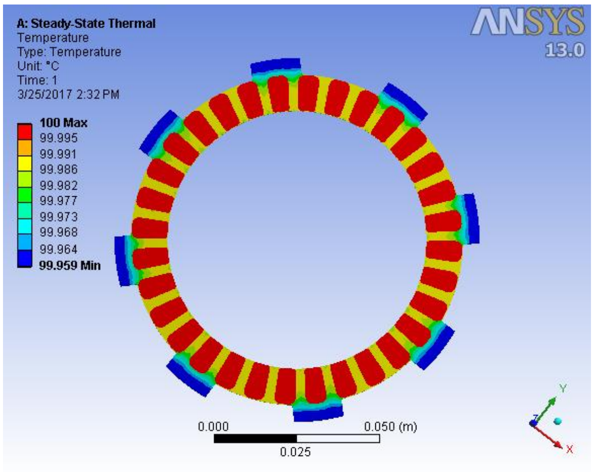


Fig -19: Temperature of Polypropylene

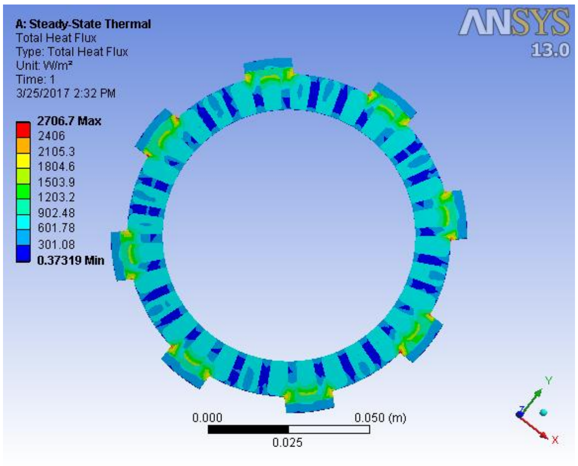
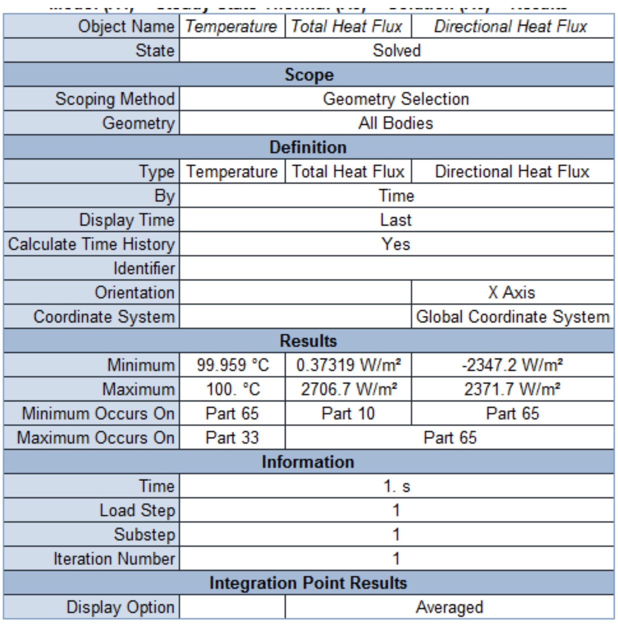


Fig -20: Polypropylene heat flux



Object Name	*Temperature*	*Total Heat Flux*	*Directional Heat Flux*
State	Solved		
Scope			
Scoping Method	Geometry Selection		
Geometry	All Bodies		
Definition			
Type	Temperature	Total Heat Flux	Directional Heat Flux
By	Time		
Display Time	Last		
Calculate Time History	Yes		
Identifier			
Orientation			X Axis
Coordinate System			Global Coordinate System
Results			
Minimum	99.959 °C	0.37319 W/m²	-2347.2 W/m²
Maximum	100. °C	2706.7 W/m²	2371.7 W/m²
Minimum Occurs On	Part 65	Part 10	Part 65
Maximum Occurs On	Part 33	Part 65	
Information			
Time	1. s		
Load Step	1		
Substep	1		
Iteration Number	1		
Integration Point Results			
Display Option		Averaged	

Fig -21: Results for polypropylene thermal analysis

6. CONCLUSION

This study explains the various characteristics and properties of the materials of Clutch Liner. The results obtained from Finite Element Analysis (FEA) are compared with original liner material values. And the analysis Alumina, Silicon Carbide, Boron Carbide are used as the materials of Clutch Liner. The Clutch Liner is sketched, modeled and assembled in AUTO CAD, Creo 2.0 and Ansys workbench. This project describes the latest and strongest alloy Clutch Liner is CARBON STEEL.

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