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Investigation of Stresses of Friction Clutch Plate on Different Material

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ABSTRACT: The purpose of clutch is to start movement or increment the speed of a body for the most part by exchanging kinetic energy from another moving body. The mass being accelerated is for the most part a pivoting inertial body. The present paper deals with designing a friction clutch assembly using CATIA Premium software. The assembly includes the clutch plate, the pressure plate and a diaphragm spring. Static and dynamic analysis was done utilizing ANSYS software. The plots for equivalent stress, total deformation and factor of safety were gotten and the plan was consistently streamlined till a protected outline was acquired. Uniform wear theory was utilized for the analysis. The material task is as per the following: clutch plate- structural steel. And the friction material is taken as steel cork.

I.INTRODUCTION

The purpose of clutch is to start movement or increment the speed of a body for the most part by exchanging kinetic energy from another moving body. Clutches are helpful in device that has two pivoting (rotating) shafts. In these devices, one shaft is normally determined by an engine or pulley, and the other shaft drives another device. Let us take an occurrence where one shaft is driven by an engine and alternate drives a penetrate throw. The clutch interfaces the two shafts so they can either be bolted together and turn at a similar speed (drew in), or be decoupled and turn at various rates (withdrew). Depending upon the introduction, speeds, material, and torque delivered lastly the utilization of the entire devices, various types of clutch are utilized. The clutch in itself is a system, which utilizes distinctive arrangements and diverse standards in different models accessible. In the accompanying lines, we have given the various types of clutch that are accessible.

A. Basic mechanism of friction Clutch

There is a rotating shaft from which power is to be transmitted, called as driver shaft; and there is a shaft to which power is transmitted, called driven shaft. To take power from driver to driven shaft clutch is engaged. Engaging the clutch means reducing the physical gap between the rotating parts and forcing the two surfaces to come in contact. Since one part is moving and the other part is stationary, there is a relative motion between them. This creates friction and as a result causes force or torque transfer.

B. Friction Clutch Actuation

Clutch actuation means engaging or disengaging the clutch such as to allow for power transmission or cut off the power or torque. Friction Clutches are mainly actuated through four means:

1. **Mechanical:** To actuate clutch mechanically liver or pedal is operated by hand or foot. These livers or pedals are connected to the friction clutch through compound linkages.

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2. **Pneumatic:** Air pressure is used to engage the clutch and disengagement is achieved through spring. Compressed air is used through pneumatic pipes and actuation is controlled through valves and pistons
 3. **Hydraulic:** Hydraulic oil is used to exert pressure on the pistons to actuate the clutch. Force is applied hydraulically through pipes and controlled by hydraulic valves and pistons.
 4. **Electrical:** For electrical actuation the levers and pedals used in mechanical actuation are replaced by electromagnet or solenoid. Clutch is engaged and disengaged by these electromagnet and solenoid on being triggered by the operator through the electrical wires instead of compound linkages, as in case of mechanical actuation.
- The clutches are designed in different forms according to the power transmission requirements and also based on design and space constraints.

II. LITERATURE SURVEY

The paper published by Mamta G. Pawar Clutch system is among the main systems inside a vehicle. Clutch is a mechanical device located between a vehicle engine and its transmission and provides mechanical coupling between the engine and transmission input shaft. Clutch system comprise of flywheel, clutch disc plate and friction material, pressure plate, clutch cover, diaphragm spring and the linkage necessary to operate the clutch. The clutch engages the transmission gradually by allowing a certain amount of slippage between the flywheel and the transmission input shaft. Shrikant V. Bhoyar, a simple transmission system consisting of engine, clutch, gearbox and load is designed for the load lifting application. Stiffness of all the three shafts have been calculated and equivalent stiffness is calculated. Equivalent mass moment of inertia is also calculated. From this data, using the concepts given by Prof. DOW, duration of engagement period is calculated for the selected power transmission system and energy dissipated during engagement is also plotted as a function of time.

Anil Jadhav, depicts a solid modelling of multiplate clutch with PRO-E CAD package that is employed for varied automotive applications. The structural analysis of clutch plate is done over cork, copper and SA92 as friction lining materials. The analysis is carried out on ANSYS workbench to get the foremost appropriate friction material for clutch. From the analyzed results, stress, strain and total deformation values were compared for all the three materials and the best one was taken out.

Prafull. S. Thakare , Clutch is a device used in the transmission system of a vehicle to engage and disengage the transmission system from the engine. The clutch works on the principle of friction. This paper discusses detailed study of single plate clutch. In this paper, detail study of clutch and modeling of clutch is done in proe software. Assembly of different parts of the single plate clutch is also done in software.

Nitinchandra R. Patel, the centrifugal clutch offers many advantages in motor and engine drive applications. Utilizing the centrifugal clutch enables the selection of normal torque motors for running loads rather than the selection of high torque motors for starting loads. The aim of this project is to be describing the torque carrying capacity at different speed which using in transmitting power.

V Mani KiranTipirineni, the driven plate used in Leyland Viking Vehicle is analyzed in this work. The driven main plate failed normally during its operation due to cyclic loading. This project explains the structural design analysis of the clutch plate and find out the failure region by doing static analysis in ANSYS software. The 3D model of clutch plate was drafted using Solid works software and analysis of the plate was done for static loading condition. This project finds the maximum stress in failure region during operation.

B. Sreevani, M.Murali Mohan, A single plate clutch is designed and modeled using Creo 2.0 software. Static analysis and Dynamic analysis is done on the clutch to determine stresses and deformations using materials Grey Cast Iron, Aluminium alloy 7075, E Glass Epoxy and Aluminium Metal Matrix Composite.

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III. DESIGN CALCULATIONS

Specifications:

Power = 13.8 BHP @ 8500 rpm

Torque = 13.4 N-m = $13.4 \times 10^3 \text{ N} - \text{mm}$

Material used is pressed asbestos on cast iron or steel $\mu = 0.3$

Maximum operating temperature $^{\circ}\text{C} = 150 - 250$

Maximum pressure $\text{N/mm}^2 = 0.4$

r_1 and r_2 outer and inner radius of friction faces $r_1 = 109\text{mm}$ and $r_2 = 90 \text{ mm}$

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

$n_1 = 5$ and $n_2 = 4$; $n = 8$

R = mean radius of friction surfaces

For uniform pressure $R = \frac{2}{3} \left[\frac{r_1^3 - r_2^3}{r_1^2 - r_2^2} \right] = \frac{2}{3} \left[\frac{109^3 - 90^3}{109^2 - 90^2} \right] = 99.80\text{mm}$

For uniform wear $R = \frac{r_1 + r_2}{2} = \frac{109 + 90}{2} = 99.5\text{mm}$

Considering uniform pressure:

When the pressure is uniformly distributed over the entire area of the friction face then the intensity of pressure P

$$P = \frac{W}{\pi(r_1^2 - r_2^2)}$$

Where W = axial thrust with which the friction surfaces are held together.

In general frictional torque acting on the friction surfaces or on the clutch is given by

$$T = n \times \mu \times W \times R$$

n = no of pairs of friction surfaces

R = mean radius of friction surfaces

μ = coefficient of friction

$$\text{WKT } T = 13.4 \times 10^3 = 8 \times 0.3 \times W \times 99.80 = 55.94$$

$$P = \frac{W}{\pi(r_1^2 - r_2^2)} = P = \frac{55.94}{\pi(109^2 - 90^2)} = 0.00047$$

Considering uniform pressure:

When the pressure is uniformly distributed over the entire area of the friction face then the intensity of pressure

$$P = \frac{W}{\pi(r_1^2 - r_2^2)}$$

Where W = axial thrust with which the friction surfaces are held together Frictional torque acting on the friction surface or on the clutch

$$T = \mu WR$$

$$\text{WKT } T = 13.4 \times 10^3 \text{ N} - \text{mm}, R = 99.80, \mu = 0.3$$

By substituting all these values in the above equation we get W

$$13.4 \times 10^3 = 0.3 \times W \times 99.80 = 447.561$$

$$\text{Pressure } P = P = \frac{W}{\pi(r_1^2 - r_2^2)} = P = \frac{447.561}{\pi(109^2 - 90^2)} = 0.0376 \text{ N/mm}^2$$

Considering uniform axial wear:

For uniform wear $P \times r = C$ (C = constant)

Axial force required to engage the clutch $W = 2\pi C(r_1 - r_2)$

Mean radius of the friction surfaces $R = \frac{109 + 90}{2} = 99.5$

Torque transmitted $T = n \times \mu \times W \times R$

$$13.4 \times 10^3 = 8 \times 0.3 \times W \times 99.5 = 56.11$$

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The intensity of pressure is Maximum at the inner radius (r_2) of the friction or contact surface Equation may be written as $P_{max} \times r_2 = C$

$$\text{WKT total force acting on the friction surface } C = \frac{W}{2\pi(r_1-r_2)} = \frac{56.11}{2\pi(109-90)} = 0.470$$

$$P_{max} = \frac{C}{r_2} = \frac{0.470}{90} = 0.00522$$

The intensity of pressure is minimum at the outer radius (r_1) of the friction or contact surface Equation may be written as $P_{min} \times r_1 = C$

$$P_{min} = \frac{C}{r_1} = \frac{0.470}{109} = 0.00431$$

The average pressure (P_{avg}) on the friction or contact surface is given by

$$P_{avg} = \frac{\text{total force on friction surfaces}}{\text{cross-sectional area of frictional surfaces}}$$

$$P_{avg} = \frac{W}{\pi(r_1^2 - r_2^2)} = \frac{56.11}{\pi(109^2 - 90^2)}$$

IV. INTRODUCTION TO CATIA

CATIA is a one of the world's leading top of the line CAD/CAM/CAE software packages. CATIA (Computer Aided Three dimensional Interactive Application) is a multi-stage PLM/CAD/CAM/CAE business software suite created by Dassault Systems and advertised worldwide by IBM.

Different Modules in CATIA

- Sketcher
- Part Design
- Assembly Design
- Drafting
- Sheet metal

Model of Multiplate Clutch

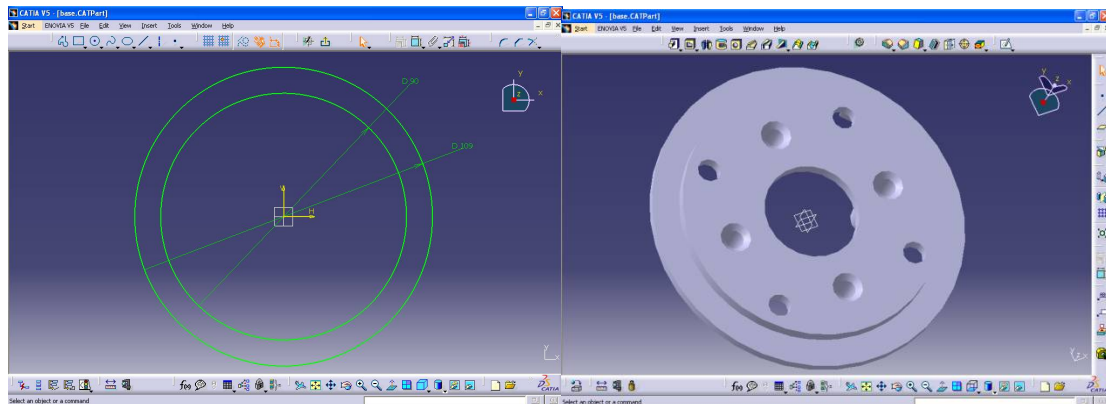


Fig 4.1: Base plate

Fig4.2: Base plate

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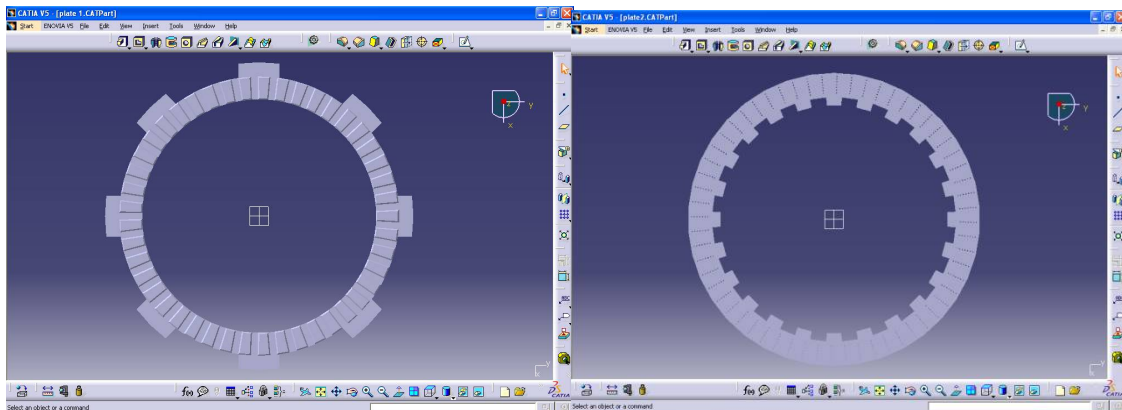


Fig4.3: Plate 1

Fig4.4: Plate 2

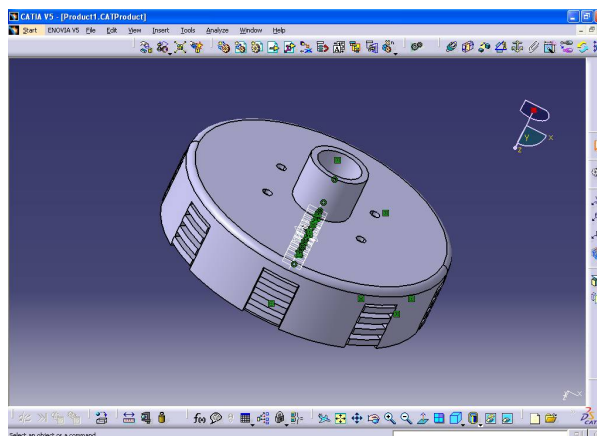


Fig4.5: Assembly of multiplate Clutch

V. ANALYSIS OF CLUTCH PLATE

ANSYS: The ANSYS Computer software is a colossal scale multipurpose finite element method program that may be used for dealing with a few classes of outlining issues. The investigation capacities of ANSYS incorporate the capacity to understand static and dynamic structural analyses, steady state and transient problems, mode frequency and buckling Eigen value problems, static or time varying magnetic analyses and different sorts of field and coupled applications. The program has many extraordinary elements which permit non-freedoms or optional impacts tube incorporated into the arrangement, such as, plasticity, large strain, hyper elasticity, creep; swelling, large deflection contact stress stiffening temperature dependency, material anisotropy and radiation. ANSYS was made, other one of a kind limits, for instance, surface arranging, sub modeling, irregular vibration, piezoelectric, coupled field analysis and outline change was added to the software. These abilities contribute further to make ANSYS a multipurpose analysis device for changed designing order.

The ANSYS program has been in business use since 1970 and it is utilized broadly in the aviation, automotive, development, electronics, vitality, benefit, fabricating, atomic or nuclear, oil and steel ventures. In addition, many counseling firms and several colleges and universities are utilize ANSYS for analysis, explore and instructive utilize.

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Structural analysis-steel and cork as friction material

Friction Material – Cork

Element Type: solid 20 nodes 95

Material Properties: Young’s Modulus (EX) : 32N/mm²

Poisson Ratio (PRXY) : 0.25

Density : 0.00000018kg/mm³

Clutch material-steel

Material Properties: Young’s Modulus (EX) : 205000N/mm²

Poissons Ratio (PRXY): 0.29

Density : 0.00000785kg/mm³

Loads

Pressure – 0.00522N/mm²

CORK – STEEL

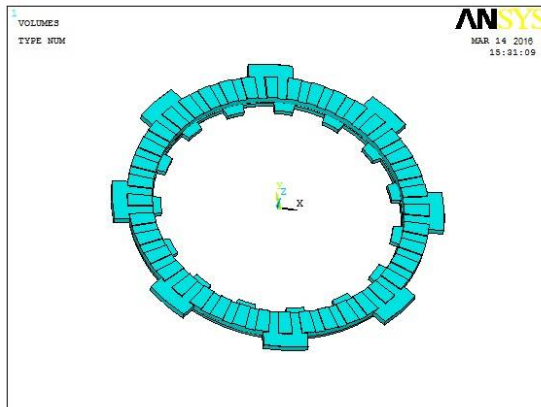


Fig 5.1IGES model

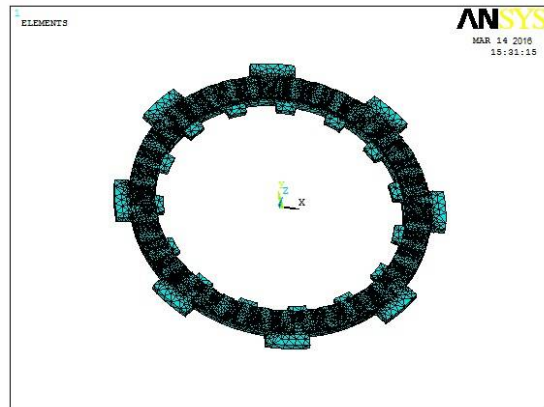


fig 5.2 Meshed model

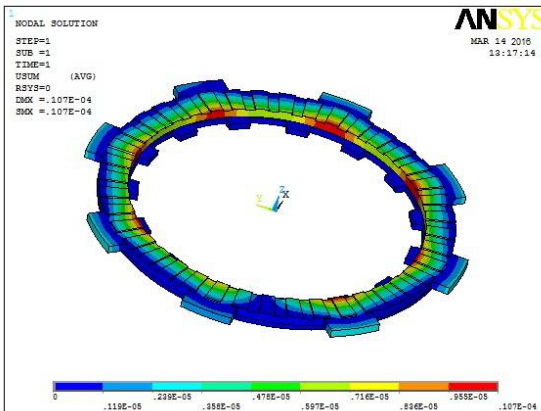


fig5.3Displacement Vector Sum

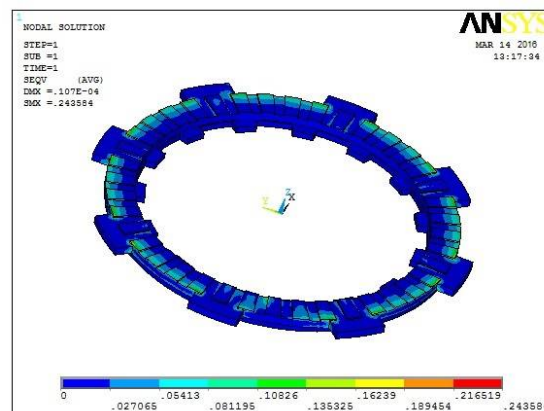


fig 5.4Von Mises Stress

DYNAMIC ANALYSIS

Set Units-/units,si,mm,kg,sec,k

Preferences- strucutral

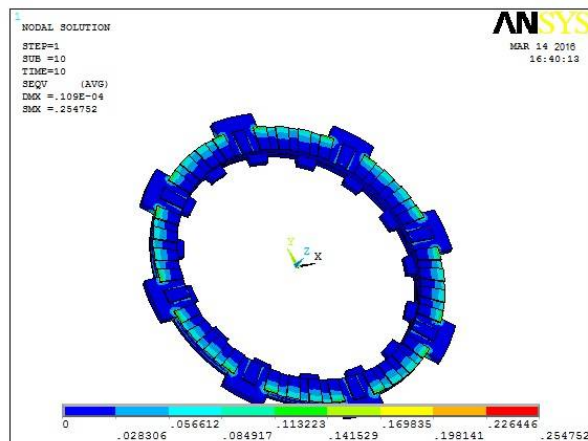
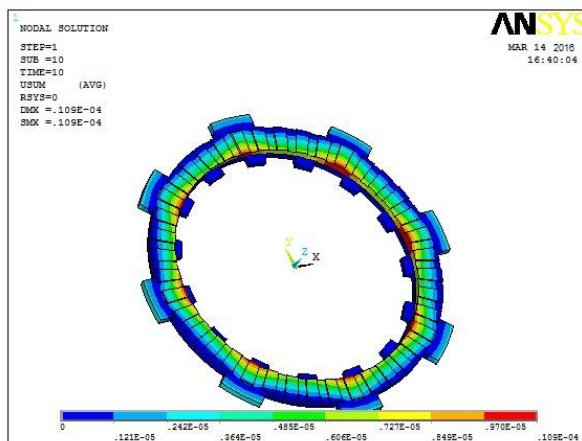
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Preprocessor – element type - add/edit/delete- add- solid 20 node 95-ok
Solutions-Analysis type-new analysis-transient- ok- full-ok.
Solutions ctrls-time at endof load step-10sec
Number of substeps-10
Max no of substep-10
Min no of substeps-1
Loads- define loads- apply- structural- displacement – on Areas-ok
Pressure -on Areas- 0.00522N/mm^2 -ok
Delete all loads-ok
Solutions ctrls-time at endof load step-20sec
Number of substeps-10
Max no of substep-10
Min no of substeps-1
Loads- define loads- apply- structural- displacement – on Areas-ok
Pressure -on Areas- 0.01044 N/mm^2 -ok
Delete all loads-ok
Solutions ctrls-time at endof load step-30sec
Number of substeps-10
Max no of substep-10
Min no of substeps-1
Loads- define loads- apply- structural- displacement – on Areas-ok
Pressure -on Areas- 0.01566 N/mm^2 -ok
Delete all loads-ok
Solution- solve – From l.s files –1-3- ok



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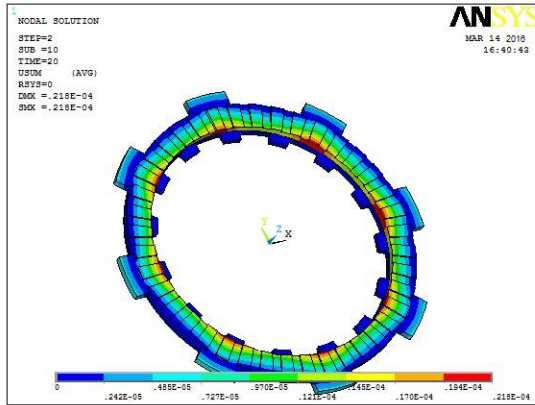


fig5.720 Secs displacement vector sum

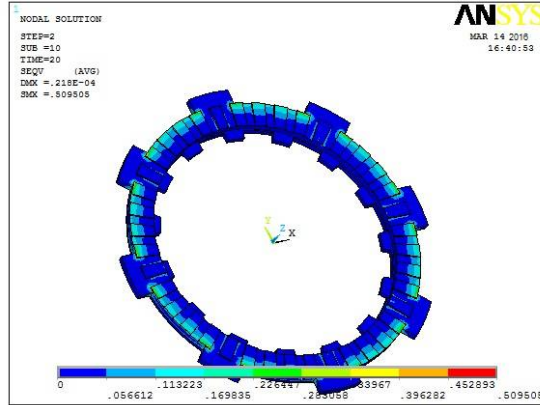


fig 5.820secs von mises stress

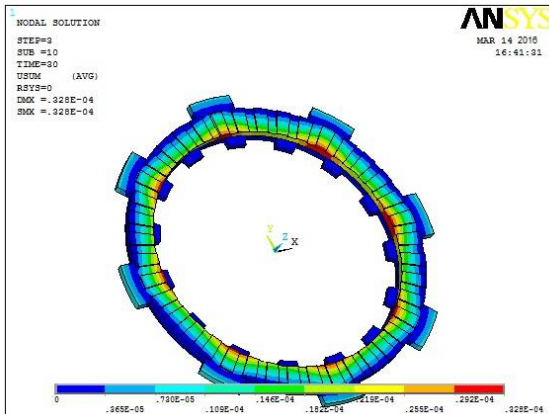


fig5.930Secs displacement vector sum

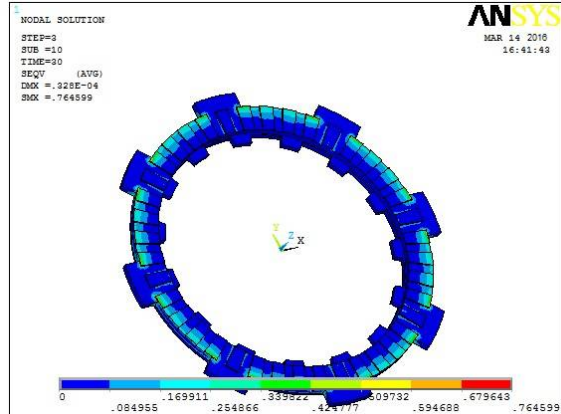


fig 5.1030secsvonmises stress

STRUCTURAL ANALYSIS-STEEL AND SF001 AS FRICTION MATERIAL

SF001

Material Properties: Youngs Modulus (EX) : 7000N/mm²

Poissons Ratio (PRXY) : 0.45

Density : 0.00000135kg/mm³

STEEL

Material Properties: Youngs Modulus (EX) : 205000N/mm²

Poissons Ratio (PRXY) : 0.29

Density : 0.00000785kg/mm³

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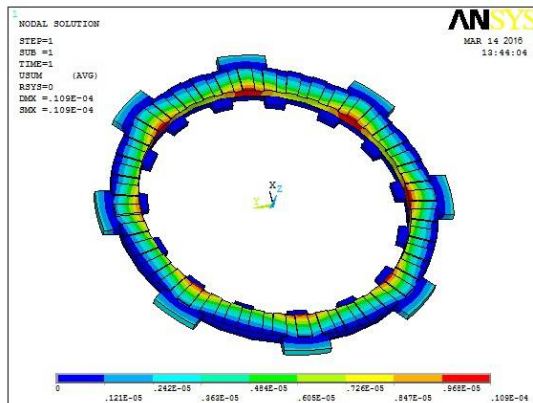


fig5.11 Displacement

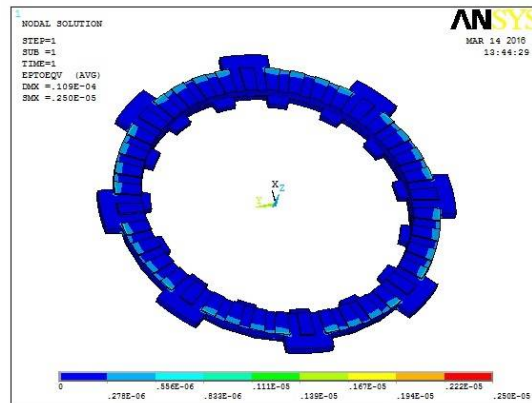


fig 5.12 Von Mises stress

DYNAMIC ANALYSIS

Set Units-/units,si,mm,kg,sec,k

Preferences- strucutral

Preprocessor – element type - add/edit/delete- add- solid 20 node 95-ok

Solutions-Analysis type-new analysis-transient- ok- full-ok.

Solutions ctrls-time at endof load step-10sec

Number of substeps-10

Max no of substep-10

Min no of substeps-1

Loads- define loads- apply- structural- displacement – on Areas-ok

Pressure -on Areas-0.00522N/mm²-ok

Delete all loads-ok

Solutions ctrls-time at endof load step-20sec

Number of substeps-10

Max no of substep-10

Min no of substeps-1

Loads- define loads- apply- structural- displacement – on Areas-ok

Pressure -on Areas-0.01044 N/mm²-ok

Delete all loads-ok

Solutions ctrls-time at endof load step-30sec

Number of substeps-10

Max no of substep-10

Min no of substeps-1

Loads- define loads- apply- structural- displacement – on Areas-ok

Pressure -on Areas-0.01566 N/mm²-ok

Delete all loads-ok

Solution- solve – From l.s files –1-3- ok

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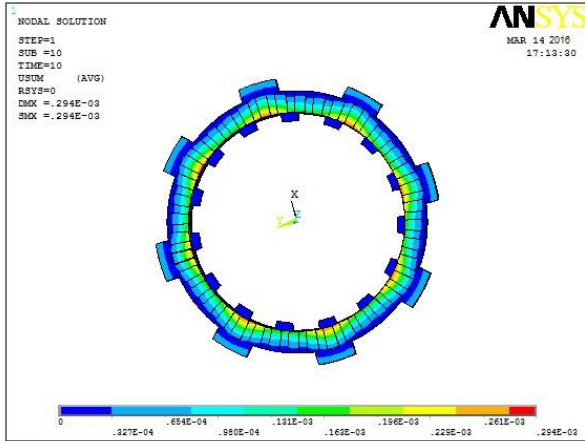


fig5.1310Secs displacement vector sum

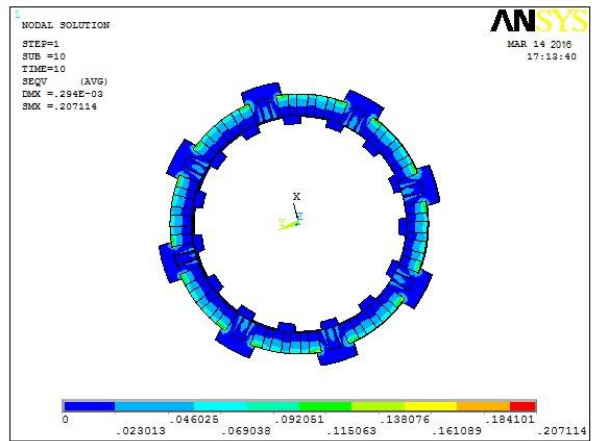


fig 5.1410secsvon mises stress

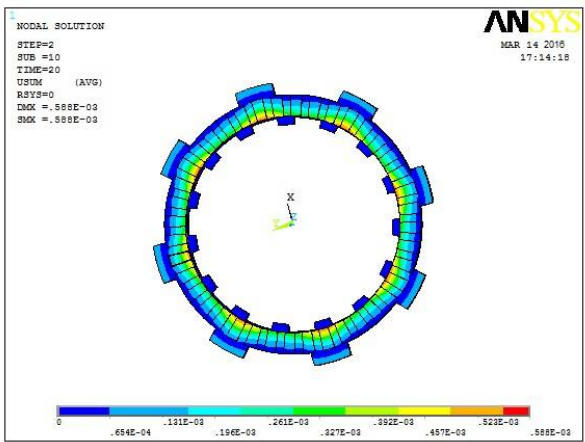


fig5.1520 Secsdisplacement vector sum

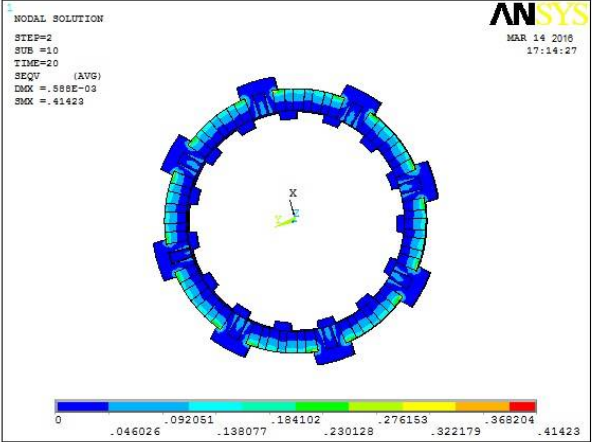


fig 5.1620 secsvonmises stress

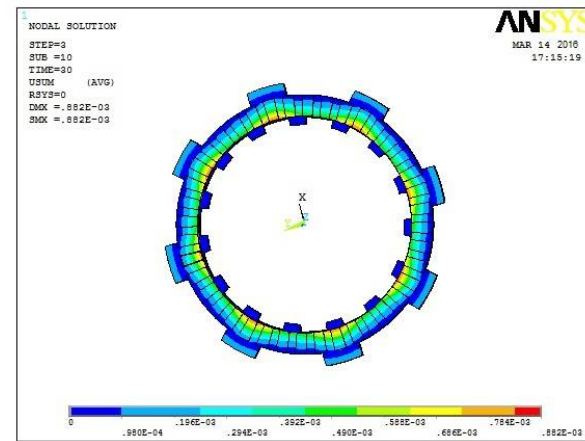


fig5.1730Secsdisplacement vector sum

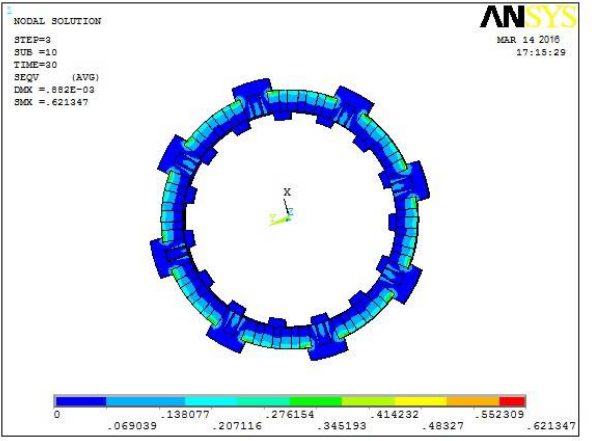


fig 5.1830secsvonmises stress

Structural analysis-aluminium alloy 6061 and cork as friction material

Cork-AL6061 Alloy

Material Properties: Young's Modulus (EX) :69000N/mm²

Poisson's Ratio (PRXY) : 0.33

Density : 0.000027kg/mm³

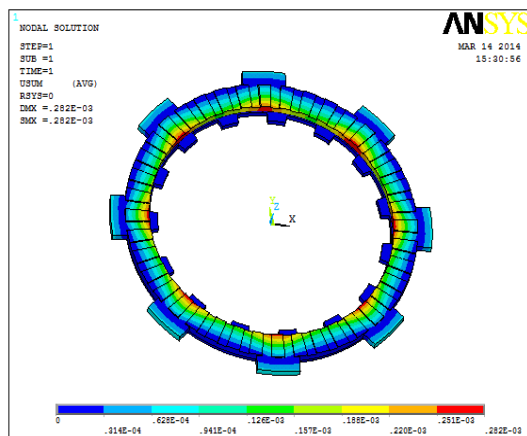


fig5.19Displacement

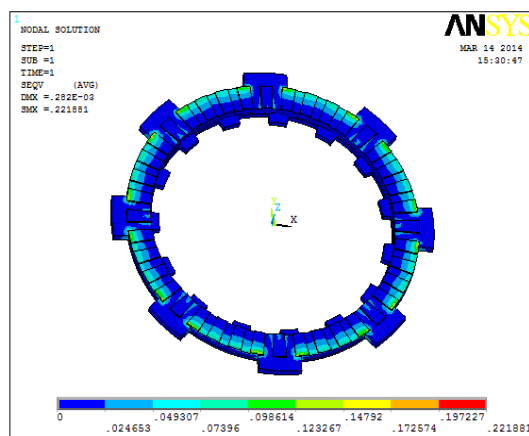


fig 5.20stress

Dynamic analysis

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Preferences- strucutral

Preprocessor – element type - add/edit/delete- add- solid 20 node 95-ok

Solutions-Analysis type-new analysis-transient- ok- full-ok.

Solutions ctrls-time at endof load step-10sec

Number of substeps-10

Max no of substep-10

Min no of substeps-1

Loads- define loads- apply- structural- displacement – on Areas-ok

Pressure -on Areas-0.00522N/mm²-ok

Delete all loads-ok

Solutions ctrls-time at endof load step-20sec

Number of substeps-10

Max no of substep-10

Min no of substeps-1

Loads- define loads- apply- structural- displacement – on Areas-ok

Pressure -on Areas-0.01044 N/mm²-ok

Delete all loads-ok

Solutions ctrls-time at endof load step-30sec

Number of substeps-10

Max no of substep-10

Min no of substeps-1

Loads- define loads- apply- structural- displacement – on Areas-ok

Pressure -on Areas-0.01566 N/mm²-ok

Delete all loads-ok

Solution- solve – From l.s files –1-3- ok

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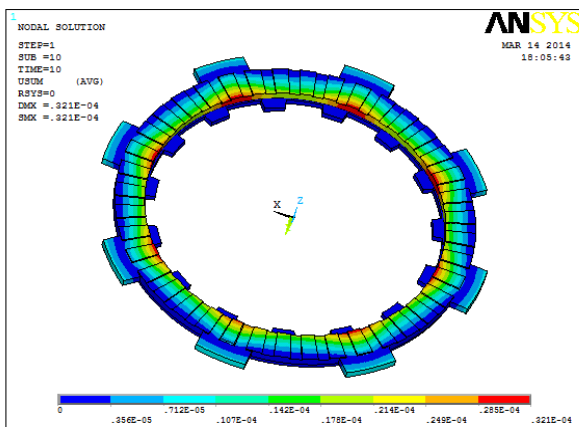


fig5.2110Secs displacement vector sum

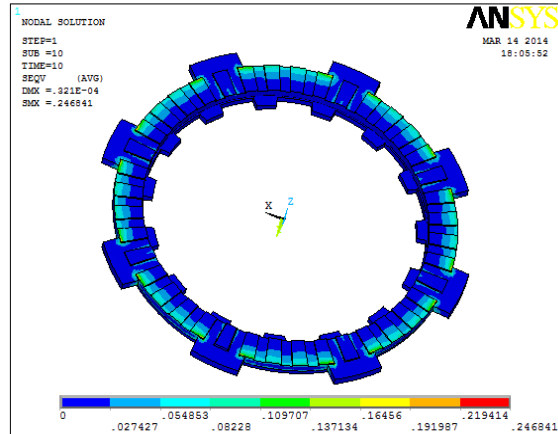


fig 5.2210secsvon mises stress

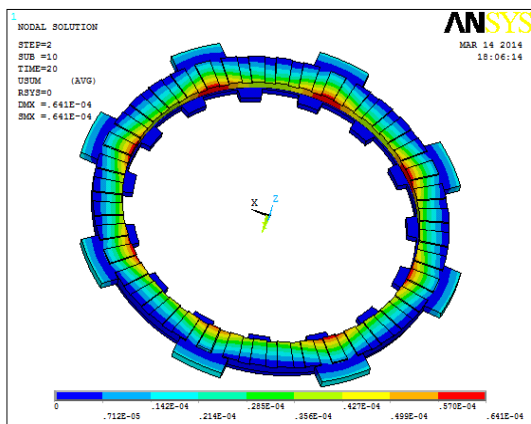


fig 28 5.23Secsdisplacement vector sum

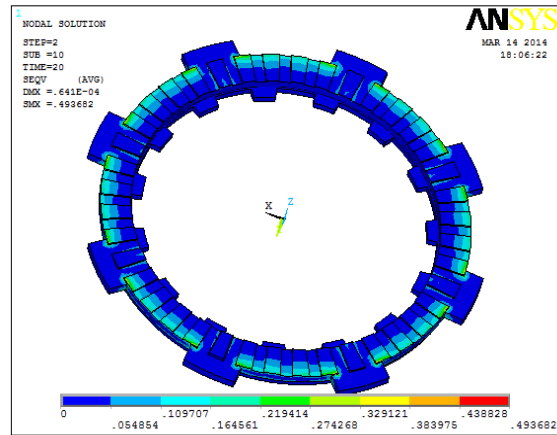


fig 5.2420secsvonmises stress

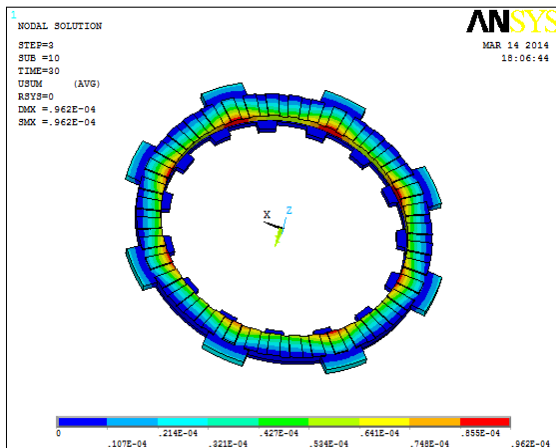


Fig 5.2530Secsdisplacement vector sum

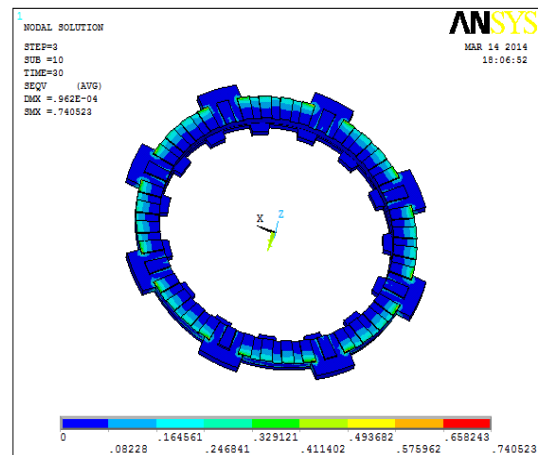


fig 5.2630secs von mises stress

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Structural analysis-aluminium alloy 6061 and SF001 as friction material

SF001 – AL6061 alloy

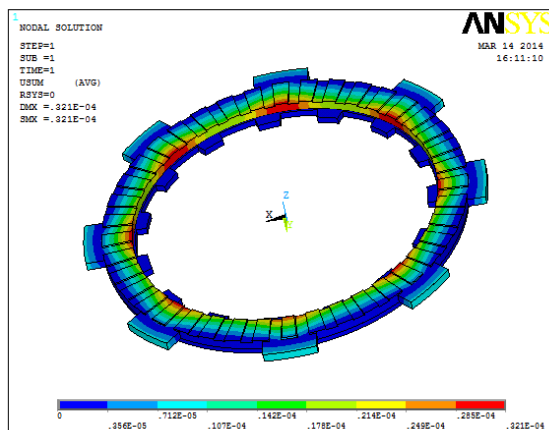


Fig 5.27 Displacement

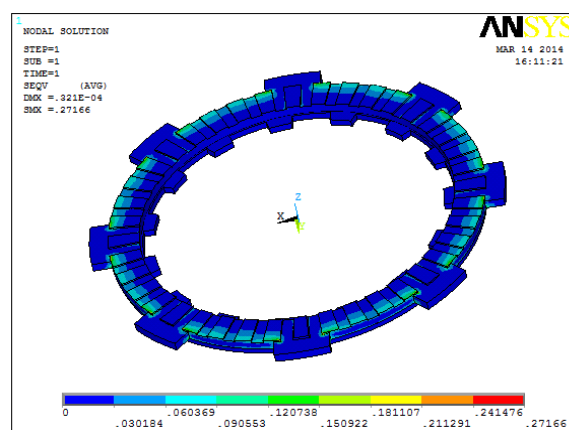


fig 5.28 stress

Dynamic analysis

Set Units-/units,si,mm,kg,sec,k

Preferences- strucutral

Preprocessor – element type - add/edit/delete- add- solid 20 node 95-ok

Solutions-Analysis type-new analysis-transient- ok- full-ok.

Solutions contrl-time at endof load step-10sec

Number of substeps-10

Max no of substep-10

Min no of substeps-1

Loads- define loads- apply- structural- displacement – on Areas-ok

Pressure -on Areas-0.00522N/mm²-ok

Delete all loads-ok

Solutions contrl-time at endof load step-20sec

Number of substeps-10

Max no of substep-10

Min no of substeps-1

Loads- define loads- apply- structural- displacement – on Areas-ok

Pressure -on Areas-0.01044 N/mm²-ok

Delete all loads-ok

Solutions contrl-time at endof load step-30sec

Number of substeps-10

Max no of substep-10

Min no of substeps-1

Loads- define loads- apply- structural- displacement – on Areas-ok

Pressure -on Areas-0.01566 N/mm²-ok

Delete all loads-ok

Solution- solve – From l.s files –1-3- ok

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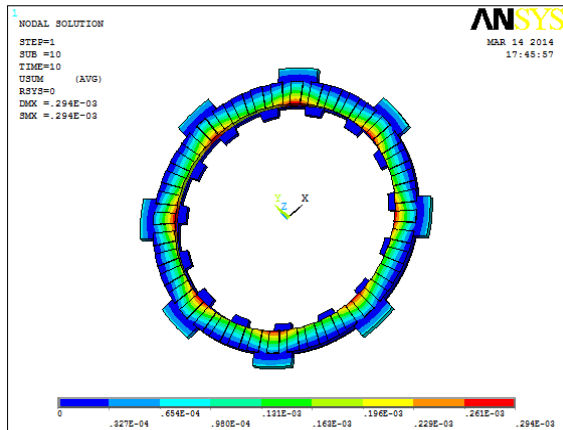


fig5.2910Secsdisplacement vectour sum

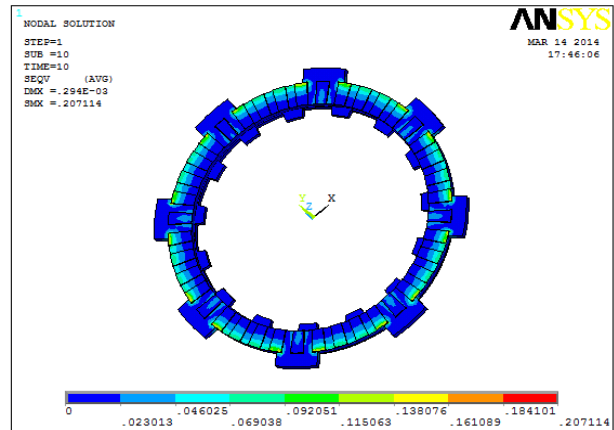


fig 5.3010secsvon mises stress

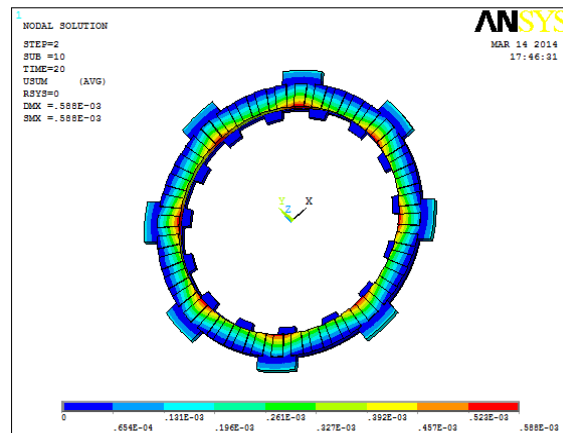


Fig 5.3120 Secsdisplacement vector sum

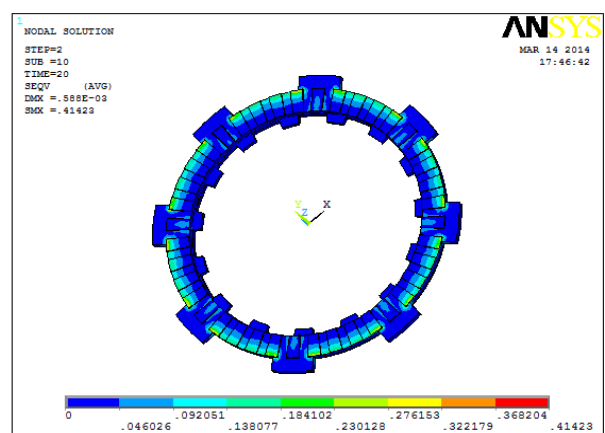


fig 5.3220secsvonmises stress

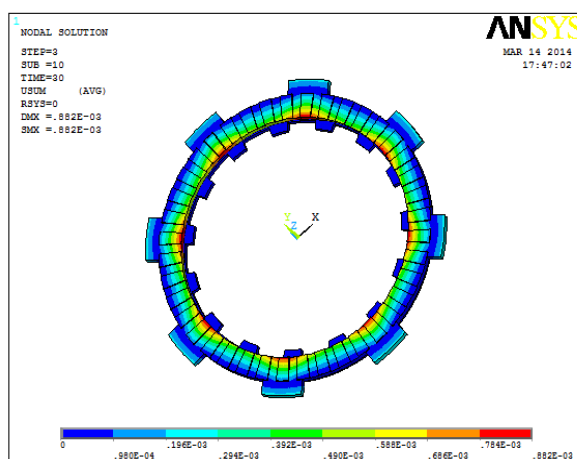


Fig 5.3330Secsdisplacement vector sum

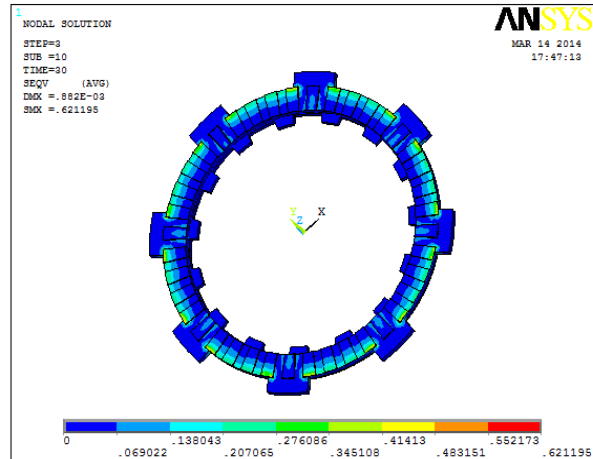


fig 5.3430secsvonmises stress

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VI. RESULTS AND DISCUSSION

Table 1 Static Result:

PROPERTIES	CORK - STEEL	SF001 - STEEL	CORK – AL6061	SF001 – AL6061
DISPLACEMENT (mm)	0.107×10^{-4}	0.109×10^{-4}	0.282×10^{-3}	0.321×10^{-4}
STRESS (N/mm ²)	0.243	0.451	0.221	0.271
STRAIN	0.130×10^{-5}	0.250×10^{-5}	0.356×10^{-4}	0.456×10^{-5}

Table 2 Dynamic results at 10 sec:

TIME = 10 SEC	CORK - STEEL	SF001 - STEEL	CORK – AL6061	SF001 – AL6061
DISPLACEMENT (mm)	0.109×10^{-4}	0.294×10^{-3}	0.321×10^{-4}	0.294×10^{-3}
STRESS (N/mm ²)	0.254	0.207	0.246	0.207
STRAIN	0.136×10^{-5}	0.330×10^{-4}	0.388×10^{-5}	0.330×10^{-4}

Table 3 Dynamic results at 20 sec:

TIME = 20 SEC	CORK - STEEL	SF001 - STEEL	CORK – AL6061	SF001 – AL6061
DISPLACEMENT (mm)	0.218×10^{-4}	0.588×10^{-3}	0.641×10^{-4}	0.588×10^{-3}
STRESS (N/mm ²)	0.509	0.414	0.493	0.414
STRAIN	0.272×10^{-5}	0.660×10^{-4}	0.776×10^{-5}	0.660×10^{-4}

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Table 4 Dynamic results at 30 sec:

TIME = 30 SEC	CORK - STEEL	SF001 - STEEL	CORK – AL6061	SF001 – AL6061
DISPLACEMENT (mm)	0.328×10^{-4}	0.882×10^{-3}	0.962×10^{-4}	0.882×10^{-2}
STRESS (N/mm ²)	0.764	0.621	0.740	0.621
STRAIN	0.408×10^{-5}	0.990×10^{-4}	0.116×10^{-4}	0.990×10^{-4}

VII. CONCLUSION

In our project we have designed a multi plate clutch using theoretical calculations.

2D drawings are drafted from the calculations. 3D model of the multi plate clutch parts and assembly are done in CATIA software.

Structural and dynamic analysis is done on the friction plates to verify the strength.

Friction materials used are Cork and SF001. Materials used for clutch plate is steel and aluminum alloy 6061.

By observing the analysis results, the stress values for cork and SF001 are less than their respective values. So our design is safe.

The displacement and stress values are less using SF001 than using cork. By using the clutch plate material as Aluminum alloy 6061, the density of the multi plate clutch is less thereby reducing the weight of the clutch.

So we conclude that for multi plate clutches using SF001 as friction material is advantageous than using cork as friction material and Aluminum alloy 6061 as clutch material is better.

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