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MODELING AND SIMULATION OF MULTI- PLATE CLUTCH ASSEMBLY TO ANALYZE THE PROPERTY VARIATION OF FRICTION PLATE

***Anshul Ahuja[1], Navdeep Malhotra[2] and Md. Quaiyum Ansari[3]**

[1]M.Tech, [2]Professor, YMCA UST Faridabad. [3]Research Scholar, IIT, Delhi

ABSTRACT

Clutch is one of the fundamental segments in cars. It is situated between the motor and the apparatus box. The fundamental capacity of the clutch is to start the movement or increment the speed of the vehicle by exchanging active vitality from the flywheel. The present paper manages the outlining and investigation of behavior of clutch plates assembled in multi-plate clutch. Research is aimed to find the property variation of each friction plate while bearing torque, axial thrust and reaction from the bearing supports. The analysis is aimed to find the critical friction plate which has more probability to wear. The Configuration has done by utilizing SOLIDWORKS programming and static auxiliary examination conveyed by utilizing ANSYS.

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Keywords: *clutch, friction, solid works, ANSYS.*

1.Introduction

A Clutch is a machine which gets together with a reiteration of frictional and turning parts which help to exchange torque intentionally. The Clutch is the middle component used to give controlled transmission amongst driving and driven shaft. The default condition of the clutch is locked in the association amongst motor/engine and gearbox is considered as "on" condition unless the driver presses the pedal and separates it. During this separation, the motor/engine is running but the transmission of power is impartial, that causes no power is transmitted to the wheels [1].

In the broad way of classification, there are two main types of clutch i.e. positive or mechanical type and frictional clutch. Mechanical type clutch used to get engagement through the grooves but they have certain inconveniences, such as they can't be locked in at higher speed. These disadvantages are overcome in frictional contact clutch. Friction clutches are also mainly divided into single friction plate and multi-friction plate.

Many researchers proposed their researchers which shown the only simulation of the behavioral properties of the individual friction plate while analyzing a multi plate clutch assembly. Very fewer researchers have shown the proof of uniformity in the behavior of each plate of the multi-plate clutch. It cannot be considered to be uniform behavior change in the each friction plate, to analyze the property variation of each plate a design model has to be made so that further analysis could have proceeded.

2. Nomenclature snd selection of materials

2.1 Kevlar as a friction material

Kevlar was the initiator of natural fiber with adequate rigidity and modulus to be utilized as a part of cutting edge composites. Initially, Kevlar was created as a substitution for steel in spiral tires; Kevlar is presently utilized as a part of an extensive variety of uses. Kevlar 49 is the enrolled trademark for a para-aramid manufactured fiber, practically identical to different aramids [3]. It was created by Stephanie K. wolek at DuPont in 1965, this high-quality material was utilized industrially without precedent for the mid-70s as are the arrangement for steel in dashing tires. Normally spun into ropes or texture sheets that could be utilized all things considered or as the fixing in composite materials. Since it has a high quality to-weight proportion Kevlar has discovered numerous applications, extending from bike tires to body protection. By this measure, it is around 5 times more grounded than steel on a proportional weight premise. As it can withstand high effect it is additionally used to make current drum lining. It is appropriate for mooring lines when utilized as a woven material, for submerged applications and for conceivable substitution as lining material.[2]

**Corresponding Author - E- mail: anshulahuja2509@gmail.com*

2.2 Design calculations

Designing of multi-plate clutch for max power $7\,hp\,(5.22\,kW)$ but average power produced will be $6.6\,hp\,(4.9\,kW)$ design should satisfy peak conditions. [6][4]

$$T = P/\omega = 5.22\,kw/3600\,rpm = 19.96\,Nm \quad (1)$$

The coefficient of friction for Kevlar $\mu = 0.35$

r_i and r_o are the inner and outer radiuses of friction faces

$r_o = 41\,mm$ and $r_i = 29\,mm$

n = no. of the pair of contact surface

$$n = n_1 + n_2 - 1 \quad (2)$$

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

$n_1 = 4, n_2 = 3, n = 6$

We are considering uniform wear theory which states that wear depends on the intensity of pressure P and velocity of rubbing and the velocity of rubbing is a function of r.

Thus for uniform wear

$$\Pr = c \text{ =constant} \quad (3)$$

For uniform wear

$$R = \frac{r_i + r_o}{2} \quad (4)$$

$R = 35\,mm$

$$T = \mu \times w \times R \times n \quad (5)$$

$19.96 = 0.35 \times w \times 0.035 \times 6$

$w = 271.29\,N$

Hence, axial force needed $w = 271.29\,N$

From uniform wear theory

$$w = 2\pi \times (P_{max} \times r_o)(r_i - r_o) \quad (6)$$

$P_{max} = 1.24\,Bar$

Area of friction plate $A = 0.00065\,mm^2$

Stress induced

$$\sigma = \frac{w}{A} \quad (7)$$

$= 0.411\,MPa$

Hence, theoretically maximum stress generation in each plate will be same and have magnitude $0.411\,MPa$

Table 1. Mechanical properties of Kevlar[2]

Properties	Specification
Density	1440
Young modulus	1.12*1011 PA
Poisson ration	0.36
Yield strength	124
Bulk modulus	1.33*1011pa
Shear modulus	4.1176 *1011 pa
Thermal conductivity	0.04
Coefficient of friction	0.35

3. Modeling of clutch assembly

A clutch assembly consists of friction plate, pressure plate, outer and inner casing. Clutch assembly is made of the solid works modeling of assembly is done for the clutch used in the 7 hp gasoline powered tiller. Power tiller is associated with a multi-plate clutch having 4 friction plates and 3 pressure plate.

Table 2. parts in assembly and material

Sl. No.	Parts	Material
1	Inner casing	Aluminum
2	Outer casing	Aluminum
3	Friction lining	Kevlar
4	Base plate	Grey cast iron
5	Pressure plate	En -150 –steel

Modeling of all parts is done in SOLIDWORKS and than the all parts are assembled.

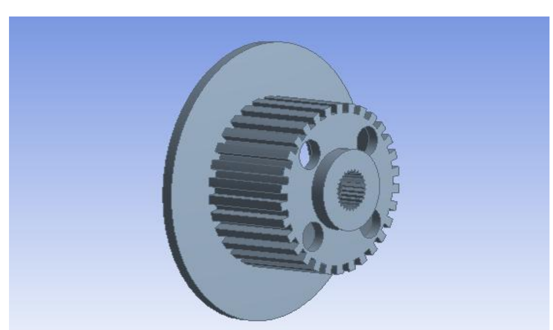

Fig .1 The inner casing of the clutch.

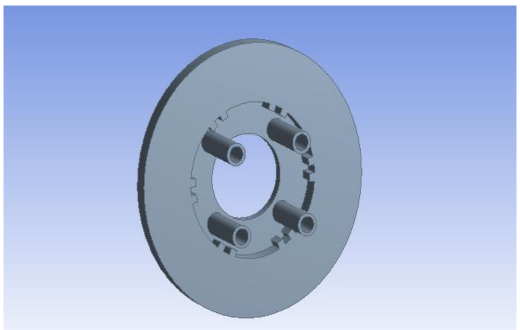

Fig. 2 The outer casing of the clutch

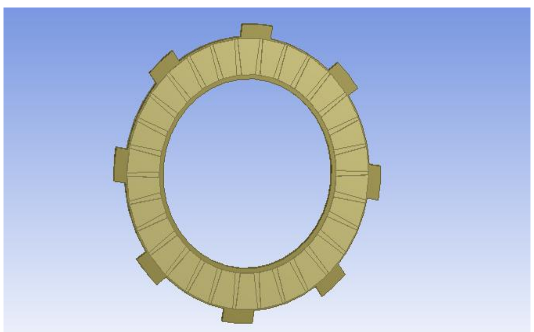

Fig. 3 A model of the friction plate in a clutch

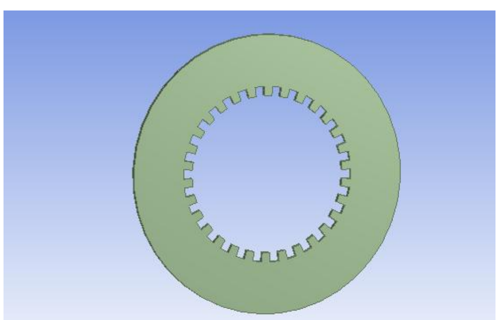

Fig. 4 The pressure plate in a clutch

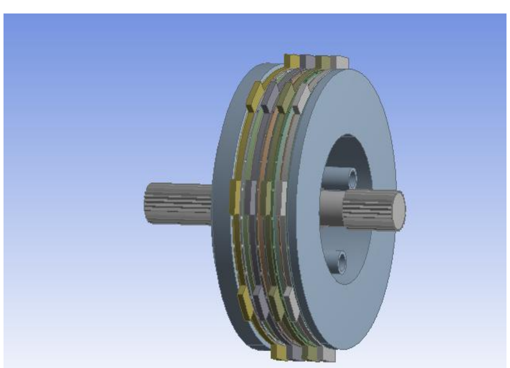

Fig. 5 A model of the clutch assembly

4. Simulation

A static analysis is done on ANSYS 14.5. Each friction plate has friction lining on both sides. So the complete assembly has eight friction linings which are bonded with their base plate and have frictional contact is considered in between the friction lining and pressure plate.

5. Result

Each friction lining is analyzed separately and their mechanical properties are simulated. Plate's numbers are given from the left side of the assembly that is from the inner casing side.

Each friction lining is taken into consideration while applying the axial force and torque on assembly. Deformation, stress, strain are found out for the each plate to judge the uniformity of behavior.

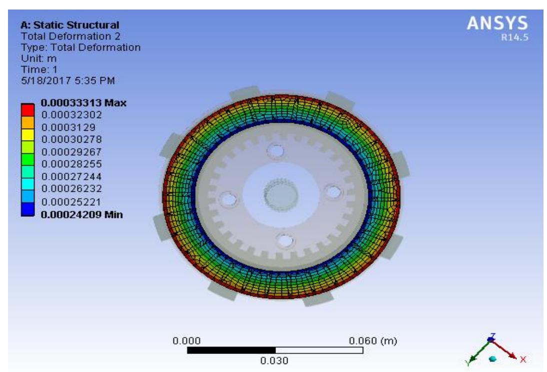

Fig. 6 The plate 1 deformation profile

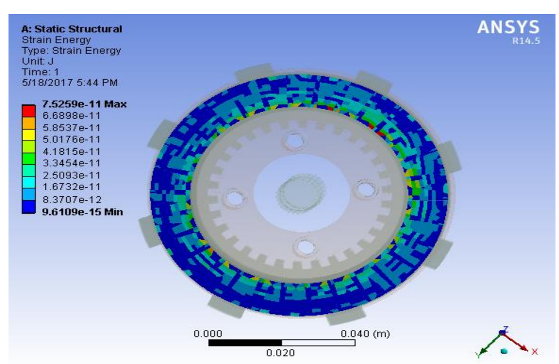

Fig. 7 The plate 1 strain energy distribution.

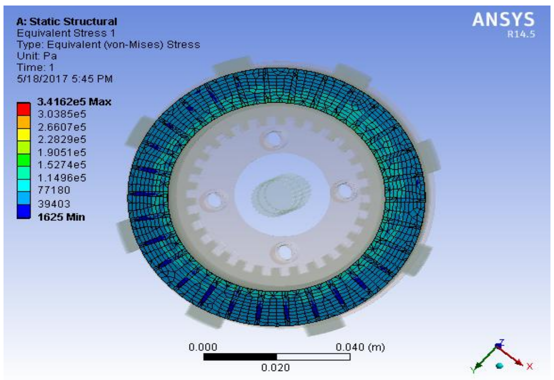

Fig. 8 The plate 1 stress distribution.

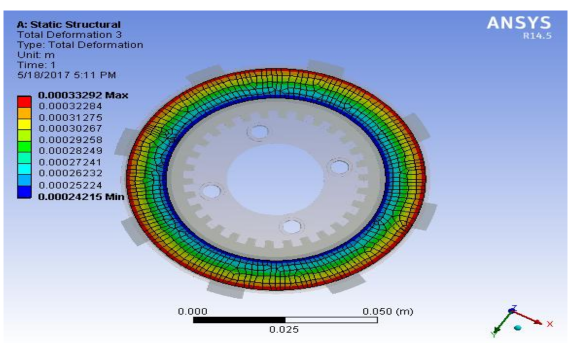

Fig. 9 The plate 2 deformation profile.

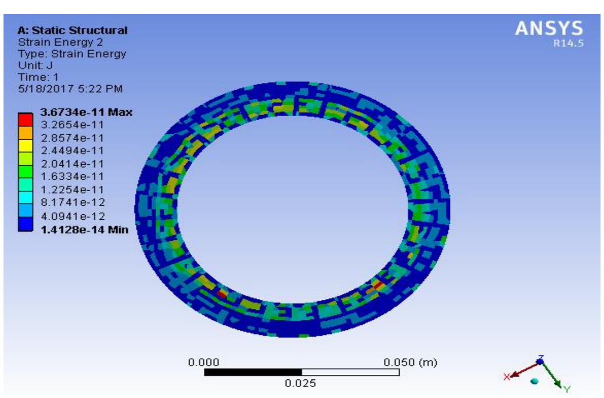

Fig. 10 The plate 2 strain energy distribution.

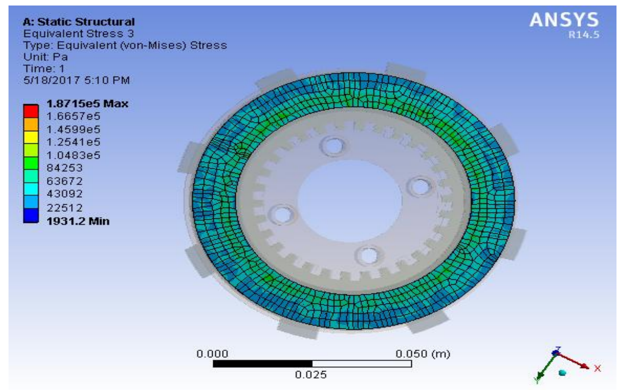

Fig. 11 The plate 2 stress distribution.

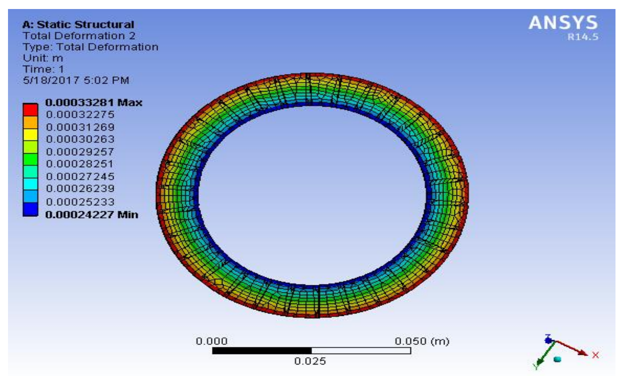

Fig. 12 The plate 3 deformation profile.

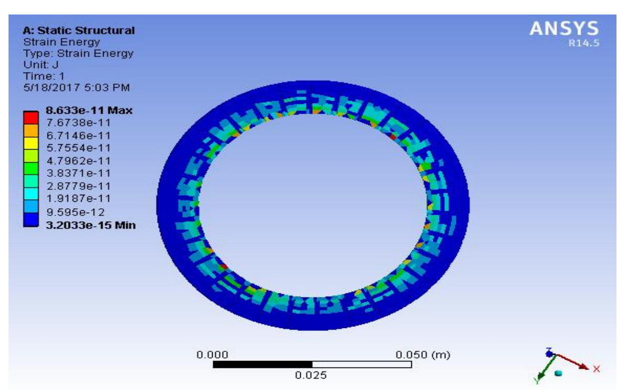

Fig. 13 The plate 3 strain energy distribution.

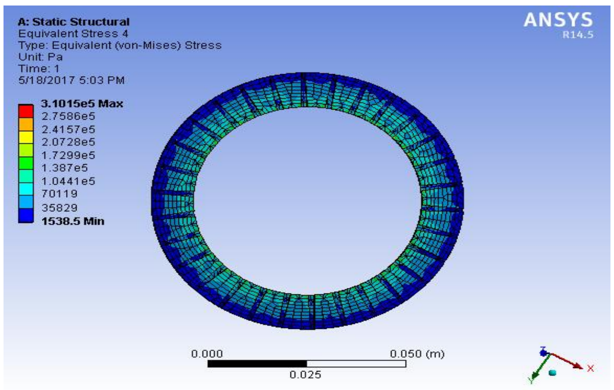

Fig. 14 The plate 3 stress distribution.

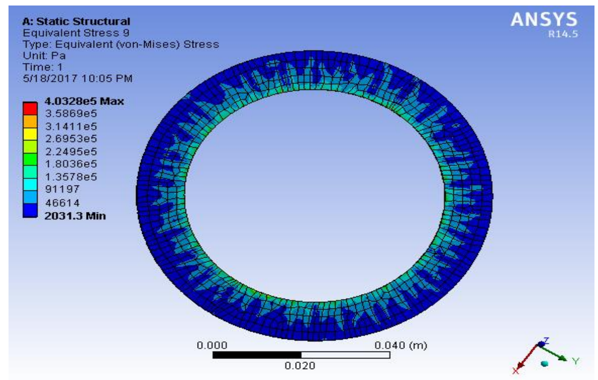

Fig. 17 The plate 4 stress distribution.

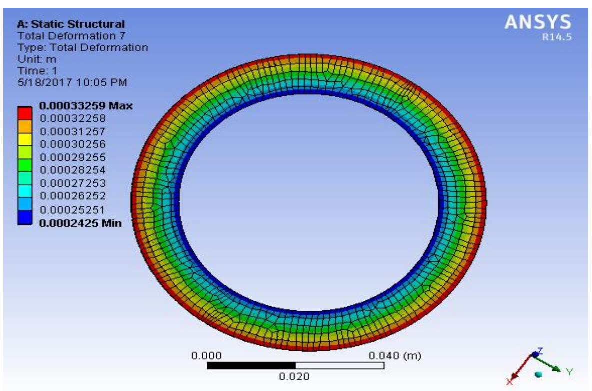

Fig. 15 The plate 4 deformation profile.

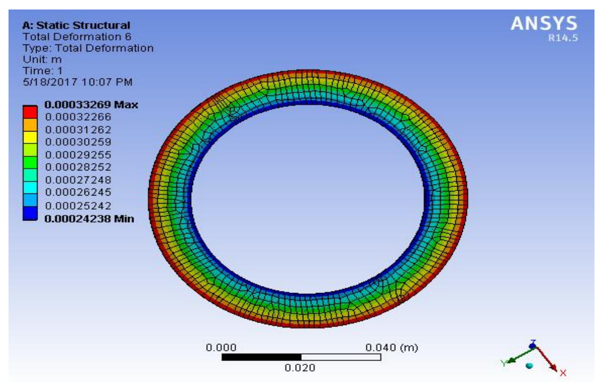

Fig. 18 The plate 5 deformation profile.

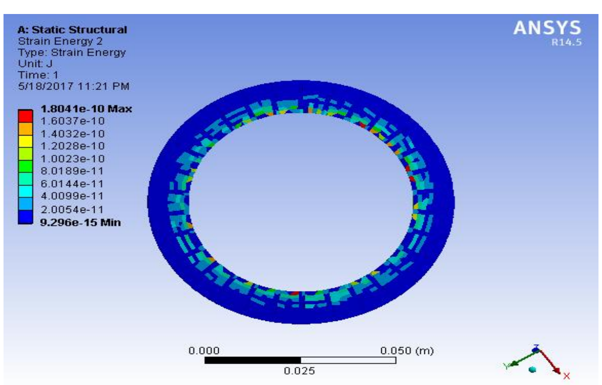

Fig. 16 The plate 4 strain energy distribution.

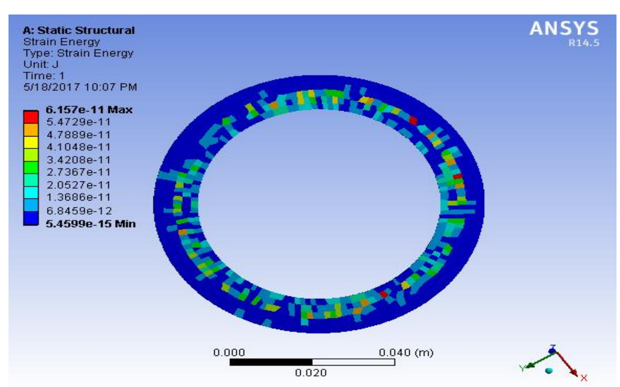

Fig. 19 The plate 5 stain energy distribution.

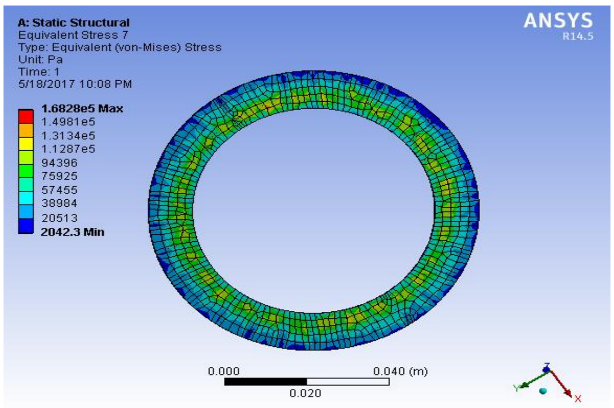

Fig. 20 The plate 5 induced stress.

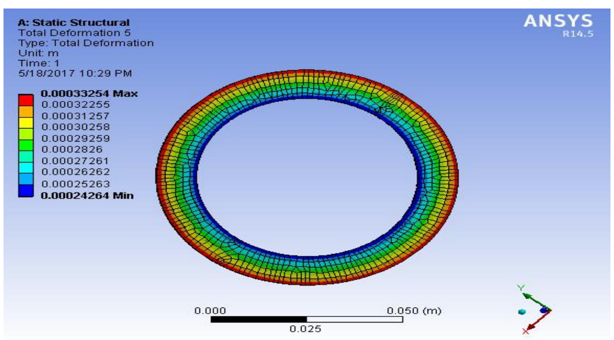

Fig. 21 The plate 6 deformation profile.

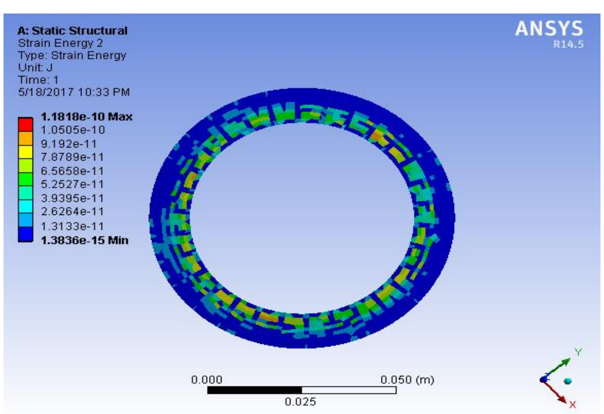

Fig. 22 The plate 6 strain energy distribution.

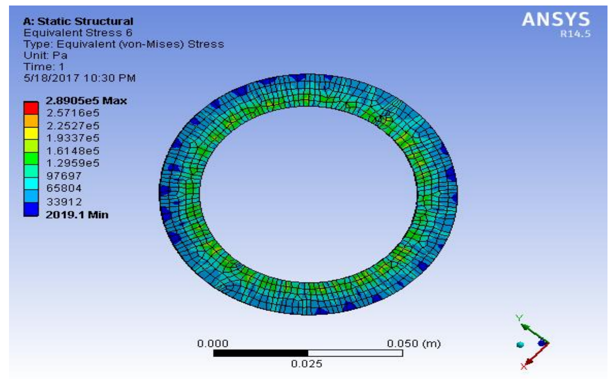

Fig. 23 The plate 6 induced stress.

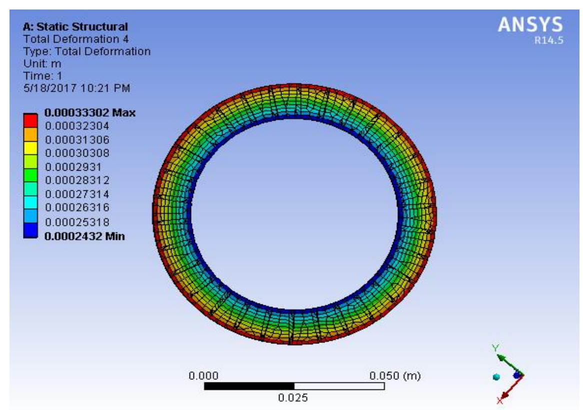

Fig. 24 The plate 7 deformation profile.

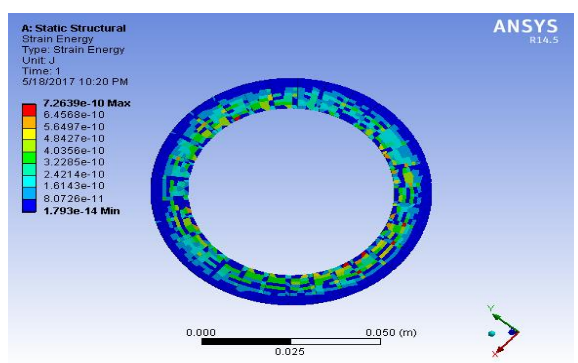

Fig. 25 The plate 7 strain energy distribution

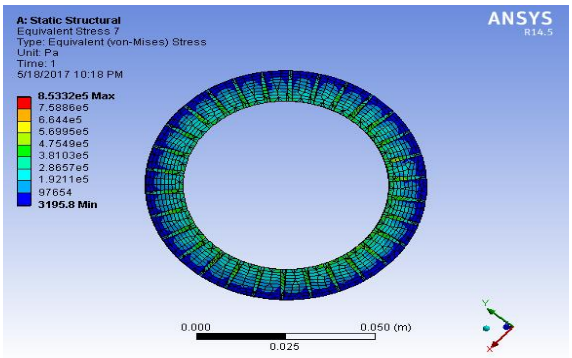

Fig. 26 The plate 7 induced stress

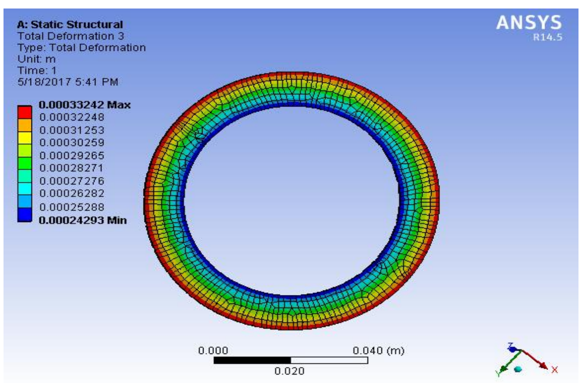

Fig. 27 The plate 8 deformation profile

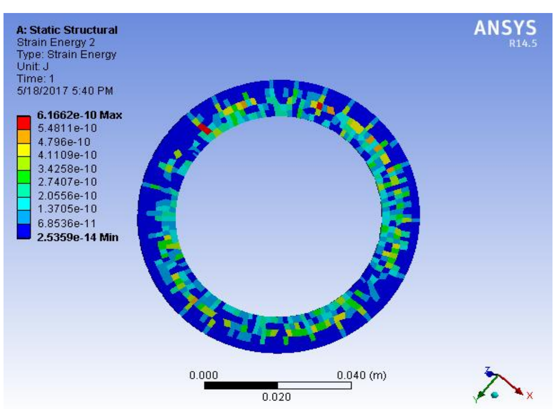

Fig. 28 The plate 8 strain energy distribution

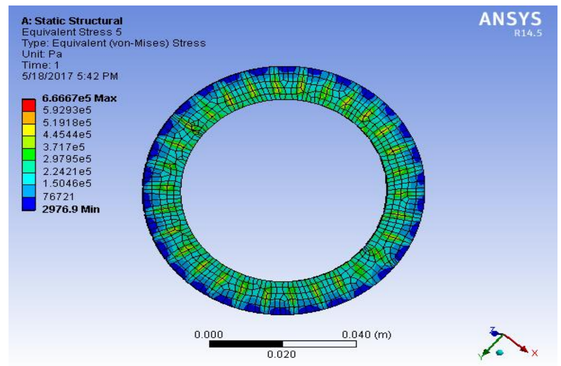

Fig. 29 The plate 8 induced stress

Simulation analysis of each plate showed different behavioral properties while working in same axial forces and torsional moment.

Table 3. A table shown below to representing all results.

Plate No.	Stress MPa	Strain energy (J)	Deformation (mm)
1	0.3410	7.52* e-11	0.00033313
2	01870	3.67* e-11	0.33292
3	0.3100	3.67* e-11	0.33281
4	0.4032	1.804*e-10	0.33259
5	0.1680	6.158*e-11	0.33269
6	0.2890	1.18*e-10	0.33250
7	0.8533	7.26*e-10	0.33302
8	0.666	6.6*e-10	0.33254

6. Conclusion

The outcomes from the result stated that there is no uniformity of property variation in each friction plate. The theoretical stress that may induce on the friction lining is 0.411 MPa and uniform for all, but Plate near to the outer casing induce stress 0.8533 MPa on casing side and 0.666MPa on the pressure plate side which is much more then other friction plates in assembly, So probability of wear and deformation in this plate is more as compared to all other. So for further analysis this friction plate just adjacent to the outer casing should considered to get more actual results.

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Nomenclature

Symbol	Meaning	Unit
T	Torque	N-m
n	Speed,	N
r1,r2	inner and outer radius of friction lining	mm
R	Mean radius of friction surface,	mm
n1,n2	No. of discs on driving and driven shafts	
W	Total operating force,	N
p	Intensity of pressure,	N/mm^2
µ	Coefficient of friction	

