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Damaged Part Analysis Using Reverse Engineering

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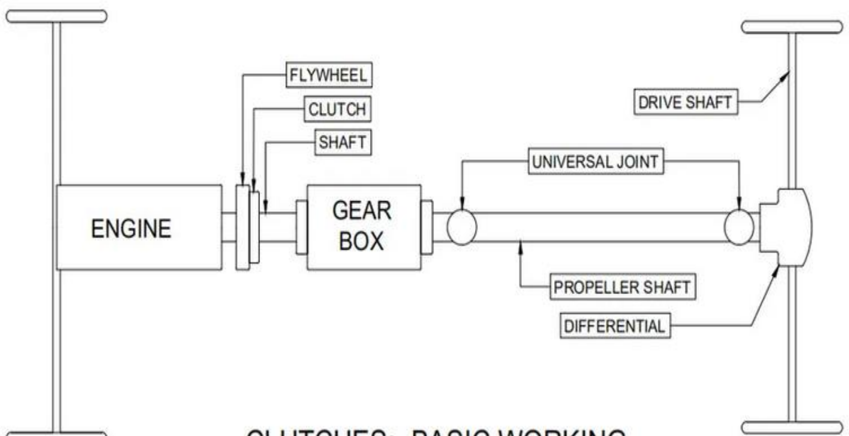
Abstract

This work presents the wear and life of single plate clutch system for this we have selected three clutch plate and made there 3D model with help of reverse engineering and then we perform steady and transient analysis on Ansys software.
Selected plate is generally selected on their wear dependence first plate is totally new and another plate is totally old (or Replaced one) but third plate is intermediate. For the analysis of these plate we added two presser plate of the same dimensional parameter. For predicting the life of clutch plate we have search the dependency of the clutch plate on various parameter and we found that our life is generally depend on two parameter first parameter is operator operation and second parameter is heat produce by the clutch plate. Our major consideration here about heat production in clutch plate and we are analyse our model depends up on this concept. When we analyse three deferent clutches we found that new clutch has good friction and grip but there is heat production is also very fast that effect the clutch plate life very rapid but after some KM run plate behaviour is change heat production in plate is reduce and small slip occur during engagement, here we also found due to less heat production our clutch life improve and these clutch hold their life for long time, But when we are considering the totally wear plate we found that there contact surface increase and friction also decrease with respect to the previous to plate but heat generation is very high due to continuous slip occurring in between the pressure plate and clutch.
Here we are comparing heat produce in clutch plate to define the remaining life and uses of clutch plate in Ansys, and we found replaced plate has more heat produce due to slip and access contact. For reducing the wear we have to increase our material property and their bonding capacity because excessive heat generation in plate generally effect it first.

Introduction

In other words we can describe it as a Clutch is a device used in a car transfer system to integrate and output a transfer system to an engine. Thus, the clutch is located between the engine and the transmission system. In a car, the clutch is always in a state of engagement. The clutch breaks when you start the engine, when you change gears, when you stop the car and when you stop the engine. It is removed using a clutch pedal that is by pressing the pedal facing down the car. The clutch is held in place when the vehicle is to move and is maintained in the direction in which the vehicle is moving. The clutch also allows for slow loading of the load, if it is working properly; restricts motor movement and thus avoids improper placing on the remaining parts of the power transmission.



CLUTCHES:- BASIC WORKING

The friction clutches of the following types are significant for the subject point of view:
1. Disc or plate clutches (single disc or multiple disc clutch),
2. Cone clutches, and
3. Centrifugal clutches.

1.2 Single Disc or Plate Clutch

A single disc or plate clutch, as shown in Fig, contains a clutch plate on both sides of the collision material (usually Ferrodo). It is fitted with a free-axis harness near the projections of the driven shaft. A pressure plate is attached inside the clutch body fastened to the flywheel. Both the pressure plate and the flywheel rotate around the engine.

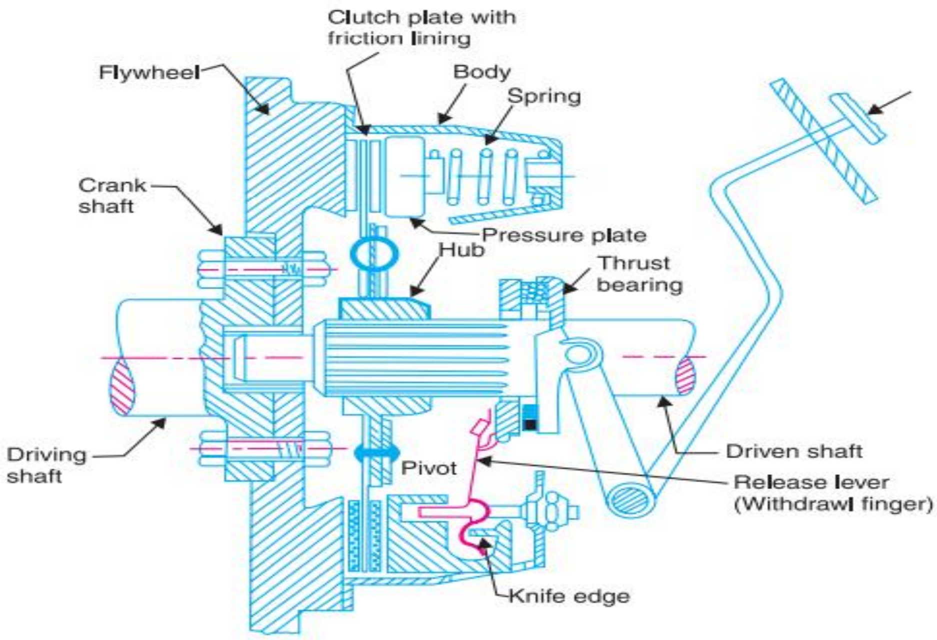


Figure. Its representation of detailed view of the clutch plate

Crankshaft or driving machine. The pressure plate thrusts the clutch plate toward the flywheel with a set of powerful springs arranged in a meter inside the body. Three beards (also known as release levers or fingers) are carried by pivots suspended in a body position. These are arranged in such a way that the pressure plate moves away from the flywheel by the internal movement of the thrust bear. The bearing is mounted on a shaft with a fork and moves forward when the clutch pedal is pressed. When the clutch pedal is pressed down, its contact forces the thrust release bearing to slide inward toward the flywheel and compress the long ends of the lever inside. The levers are forced to light up their suspended pivot and the pressure plate moves away from the flywheel with the edges of the knife, thus squeezing the clutch springs. This action removes the pressure on the clutch plate and then slides away from the flywheel and the steering shaft stops. On the other hand, when the foot is removed from the clutch pedal, the thrust bear backs up with levers. This allows the springs to expand and thus the pressure plate to push the clutch plate back in the direction of the flywheel.

Geometry Modelling

Engineering fields are constantly evolving into current designs and ways to make life easier and simpler. When referring to technology, simplicity and simplicity can be directly related to speed and accuracy. That is, you do not spend valuable time on compiling or performing a particular task. It is simple which means how many times you will need to do the process or task. When we think of engineering we think of a common definition of product design with a blue print or system. Engineering is defined as “the application of scientific and mathematical principles to the practical purposes such as the design, construction, and operation of buildings, machinery, processes, and efficient and sustainable systems”. This type of engineer is best known as Forward Engineering. The concept of emerging engineering uses advanced engineering in a backward way. This method is commonly referred to as Reverse Engineering. Postpartered engineering is the opposite of advanced engineering. It takes an existing product, and builds a CAD model, to modify or reproduce the design feature of the product. It can also be defined as a process or duplicate of an existing part by photographing body size parts. Reversible engineering is usually done to redesign the system for better storage or to produce a copy of the system without access to the original design. With this information, computer vision applications are designed to compete in a perverted engineering environment.

Figure. Stl. file of a new clutch plate.

Figure. Stl. file of a clutch having little wear on its surface.

Figure. Stl file format of a clutch having highly wear on its surface.

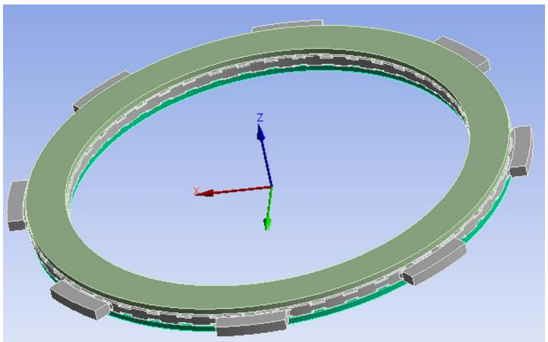


Figure. Shows 3D model of the clutch pate

Parameters	Value
Number of friction surfaces	2
Service factor (b)	1.4
Mean radius of friction disc (mm)	100.5
Clutch friction plate outer radius (mm)	118.7
Clutch friction plate inner radius (mm)	91.72
Thickness of clutch plate (mm)	2.98
Thickness of Pressure Plate (mm)	1.5
Number of friction pocket	45
Number of rivets	12
Outer Diameter Of Pressure Plate (mm)	118.7
Inner Diameter Of Pressure Plate (mm)	91.72

MATERIALS

In order to select the type of clutch (with or without dampers) and the clutch components (live or non-living) of the intended system, it is significant to consider the required factors:

(i) Wear characteristics,
(ii) Operating temperature,
(iii) Design specification,
(iv) A sense of grip,
(v) Strength.

The materials considered in this work are only used to analyse the vertical design and the impact of the groove pattern design and space on its structural and thermal performance. Two inanimate anti-paper compounds, namely FTL180 and TF1600-MC2, are considered in this study. Both have excellent performance, high friction, and a high amount of aramid fibber, which is a non-ferrous compound. He may appear in metal objects as an alternative and offer a few advantages. They are resistant to high energy input and are suitable for dry use with oils. They are inexpensive over the counter, quiet when operating, and resistant to high pressures.

Parameters	FTL180	TF1600MC2
Material type	Paper friction	Paper friction
Static friction coefficient, μ	0.41	0.30
Fading temperature (°C)	395	423
Wear rate ($mm^{3/}$kwh)	53	30
Dynamic friction coefficient, μ_d	0.36	0.4
Hardness (DIN53505)	82	85
Density (g/cm^3)	1.21	1.30
Thermal conductivity (W/m°K)	0.24	0.26
Poisson coefficient	0.28	0.30
Tensile strength (ASTM D638) - (N/mm^2)	72	70
Compressive strength (UNE 53205) - (N/mm^2)	308	306
Young modulus (ASTMD 638-10)- (N/mm^2)	7290	7260
Continuous operation, Tmax (°C)	360	360
Intermittent operation, Tmax (°C)	400	400
Max. allowable pressure (MPa)	1.034	1.034
Burst resistant (200×137×3.5) 200°C (rpm)	18180	18300

Grid Generation

The grid structure and mesh size defines the accuracy of results in numerical analysis. Good and accurate results can be obtained by using very fine meshes but it increases the computational time and the cost associated with it. Therefore, a balance is to be maintained between the grid size and the required accuracy. In this study, a grid independence test was carried out to select an optimum mesh size which produces accurate results and is computationally not very costly as well.

In our project we are making medium size grid of 0.001mm and this mesh is good for our solution. Due to this size of grid stress distribution on clutch plate is good and graphical representation is also good. We have created 253494 nodes and 134867 elements.

Table Mesh quality for Clutch plate

Specifications		Values
Number of Nodes		253494
Aspect Ratio	Maximum	12.5
	Minimum	1
	Average	1.5
Skewness	Maximum	0.90
	Minimum	0.01
	Average	0.45
Orthogonality	Maximum	1
	Minimum	0.24
	Average	0.88

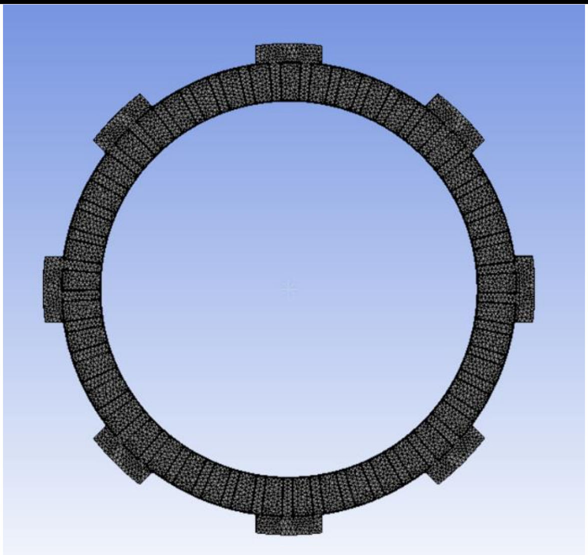


Figure. It's a representation of mesh on clutch plate

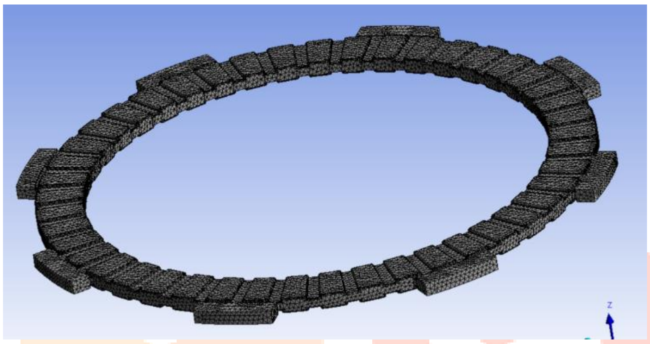


Figure. Isometric representation of mesh on clutch plate

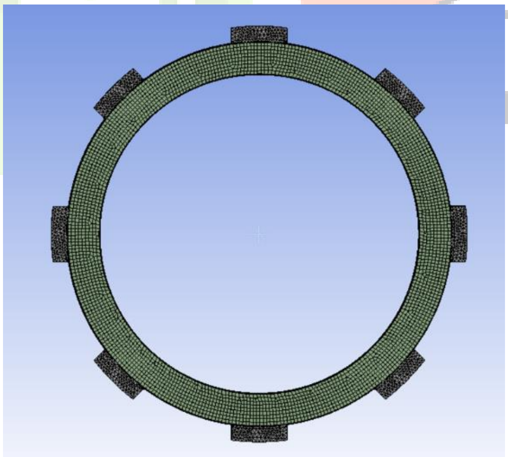


Figure. It represent the mesh distribution on the clutch plate and pressure plate.

Governing Equation

a) Frictional Torque Model

We shall now consider the following two cases:

1. When there is a uniform pressure, and

2. When there is a uniform wear.

i. Considering uniform pressure

When the pressure is uniformly dispersed over the entire area of the friction face, then the strength of pressure,

$$p = \frac{W}{\pi[(r_1^2 - r_2^2)]}$$

Where W = Axial thrust with which the contact or friction surfaces are held together. We have discussed above that the frictional torque on the elementary ring of radius r and thickness *dr* is

$$T = 2\pi\mu p r^2 \delta r$$

Integrating this equation within the limits from r_2 to r_1 for the total frictional torque.

∴ Total frictional torque acting on the friction surface or on the clutch,

$$T = 2\pi\mu p \int_{r_i}^{r_0} r^2 \delta r \quad = 2\pi\mu p[\frac{r^3}{3}]_{r_1}^{r^2} \quad = 2\pi\mu p[\frac{(r_1)^3 - (r_2)^3}{3}]$$

Substituting the value of p from equation (i),

$$T = 2\pi\mu \times \frac{W}{\pi(r_1^2 - r_2^2)} \times [\frac{(r_1)^3 - (r_2)^3}{3}]$$

$$= \frac{2}{3}\pi W \times [\frac{(r_1)^3 - (r_2)^3}{(r_1^2 - r_2^2)}] = \mu W R$$

Where R = Mean radius of friction surface

$$= \frac{2}{3}[\frac{(r_1)^3 - (r_2)^3}{(r_1^2 - r_2^2)}]$$

ii).Considering uniform wear

Let p be the normal intensity of pressure at a distance r from the axis of the clutch. Since the intensity of pressure varies inversely with the distance, therefore

$$pr = C \text{ (a constant)} \quad \text{or} \quad p = C/r \qquad ...(i)$$

And the normal force on the ring,

$$\delta W = 2\pi rp\delta r = \frac{C}{r}2\pi r\delta r = 2\pi C\delta r$$

∴ Total force acting on the friction surface,

$$\int_0^w \delta W = \int_{r_2}^{r_1} 2\pi C\delta r = 2\pi C(r_1 - r_2)$$

$$C = \frac{w}{2\pi(r_0 - r_1)}$$

$$T = 2\pi\mu pr^2\delta r$$

$$T = 2\pi\mu C\int_{r_i}^{r_0} r\delta r$$

$$T = \pi\mu C(r_1^2 - r_2^2)$$

$T = \pi\mu WR_m$, where $R_m = (r_1 + r_2)/2$

2. For a single disc or plate clutch, normally both sides of the disc are effective. Therefore, a single disc clutch has two pairs of surfaces in contact, i.e. n = 2.

3. Since the intensity of pressure is maximum at the inner radius (r_2) of the friction or contact surface, therefore equation (i) may be written as

$p_{max} \times r_2 = C$ Or $p_{max} = C / r_2$

4. Since the intensity of pressure is minimum at the outer radius (r 1) of the friction or contact surface, therefore equation (i) may be written as

$p_{min} \times r_1 = C$ Or $p_{min} = C / r_1$

5. The average pressure (p_{av}) on the friction or contact surface is given by

$$p_{av} = \frac{Total\ force\ on\ friction\ surface}{Cross-sectional\ area\ of\ friction\ surface} = \frac{W}{\pi(r_1^2 - r_2^2)}$$

6. In case of a new clutch, the intensity of pressure is approximately uniform but in an old clutch the uniform wear theory is more approximate.

7. The uniform pressure theory gives a higher frictional torque than the uniform wear theory. Therefore in case of friction clutches, uniform wear should be considered, unless otherwise stated.

During the clutch disc plan, the adoption of uniform wear theory is suggested as uniform pressure postulation gives a higher torque in most cases. Thus, a clutch disc design based on uniform pressure will result in the clutch slip when it becomes old. Assuming constant wear rate, i.e. $pr = C$, the elemental clamping force on clutch facing is given by Eq.

$$\delta W = 2\pi r p \delta r$$

$$\delta W = 2\pi C \delta r$$

$$\int_0^w \delta W = 2\pi C \delta r$$

$$C = \frac{w}{2\pi(r_0 - r_1)}$$

$$T = 2\pi\mu p r^2 \delta r$$

$$T = 2\pi\mu C \int_{r_i}^{r_0} r \delta r$$

$$T = \pi\mu C(r_0^2 - r_i^2)$$

$T = \pi\mu W r_m$, where $r_m = (r_0 + r_i)/2$

Result

The major focus of the research to predict the life of clutch plate so we have to consider some of the parameter that affect the life of the Clutch plate. Some of the major parameter is listed below.

- Energy lost during start up
- Energy Transmitted
- Max Engine Torque
- Rpm of the Engine
- Average Friction radius

As we know energy play a very vital role to decide the life of any clutch plate so we consider on energy parameter in most of the cases, so our main focus on the total defamation and energy in the Ansys analysis section.

a).Clutch life Estimation

Clutch heat stress for the manual transmission is calculated as following**.**

$$\sigma_h = \frac{Energy\,lost\,in\,friction}{Area\,of\,the\,clutch\,disk}$$

$$\sigma_h = \frac{W_{lost}}{n(\frac{\pi}{4})(OD^2 - ID^2)}$$

$$Wlost = Wt = Wengine/2 = (\pi) * Tmax * Nrpm * \frac{tslip}{60}$$

$$tslip = \frac{I * \omega}{(\mu * N * Rg - Td)}$$

$$I = \frac{GVW * DTR^2}{(Ig * \mathrm{Ir})^2}$$

$$L = \left(\frac{z}{xo}\right) * D$$

$$xo = \sigma_h * \mathrm{w} * \mathrm{n} * \mathrm{Duty\_cycle}$$

Now,

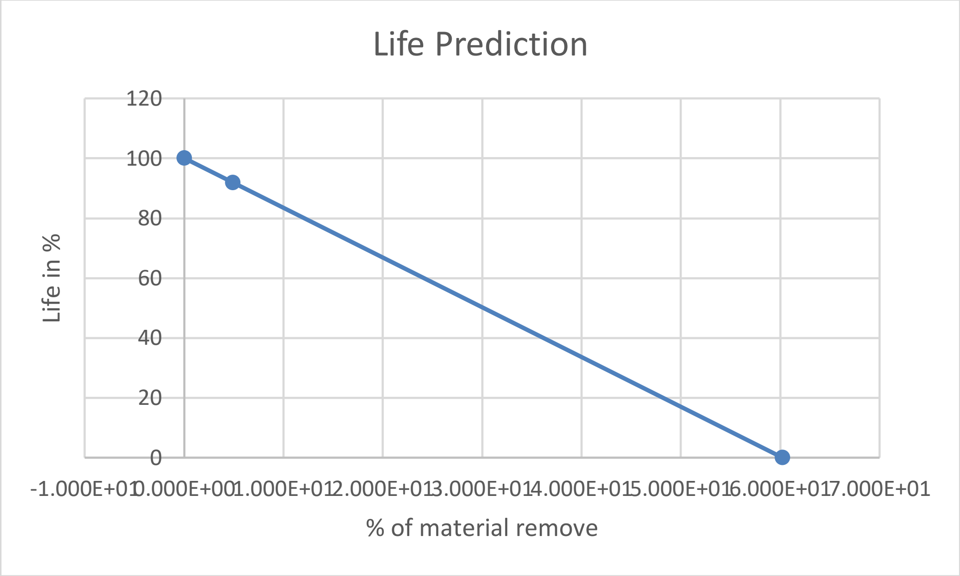
$$\mathrm{L}\, \alpha \frac{1}{xo}\, \alpha \frac{1}{\sigma_h}\, \alpha \frac{1}{Energy\ lost\ in\ friction}$$

$$\mathrm{L} = \frac{K}{Energy\ lost\ in\ friction}$$

Where

n = no. of friction surface
OD = Outer diameter of the friction Surface
π =3.14159
ID = Inner diameter of the friction Surface
W lost = Energy lost during start up
Wt = Energy Transmitted
T max = Max Engine Torque
N rpm = Rpm of the Engine
t slip = Slip Time
W engine = Energy of engine
I = Reflected inertia of the Vehicle
ω = Angular velocity of the engine
N = Normal force
Rg = Average Friction radius
Td = Drag Torque of transmission

As we found from the above relation that life of the Clutch plate is directly depends up no the energy lost by the clutch plate so we are going to evaluate various parameter at directly or indirectly related to energy.



Heat loss vs Life of clutch

b) Total deformation of the Clutch plate

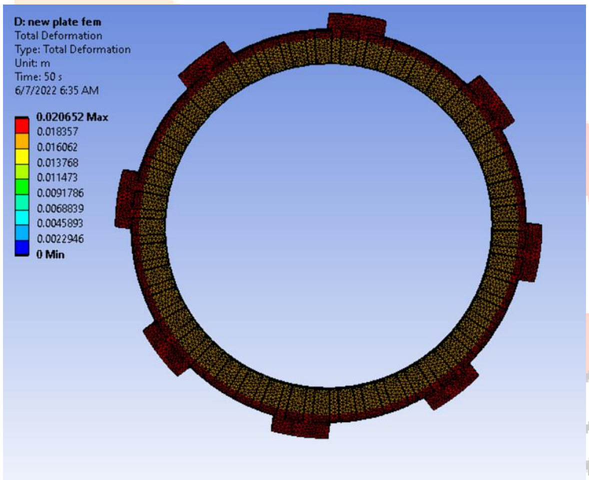


Figure. It show the total deformation of new clutch plate

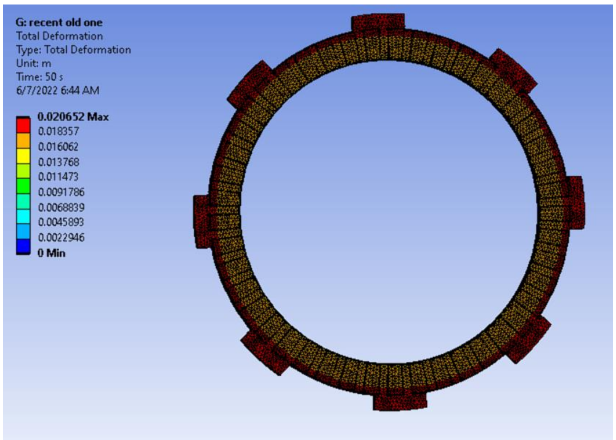


Figure. It show the total deformation of less use clutch plate.

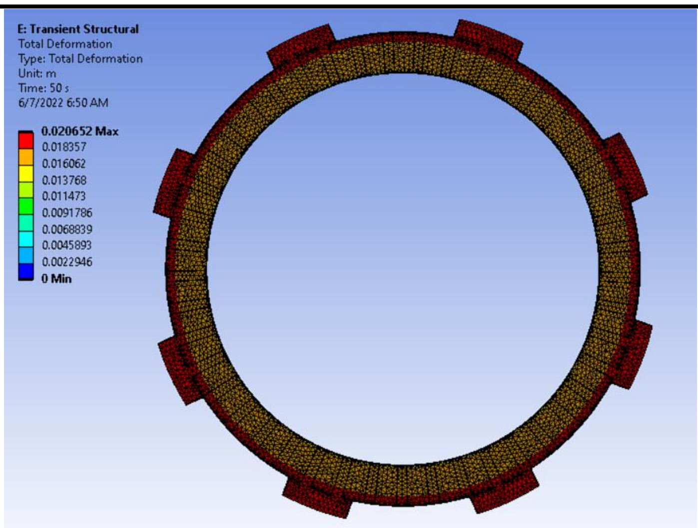


Figure. It show the total deformation of Replaced clutch plate.

According to the results deformation occurred in the new plate is more that the used just used plate and more deformation occurred in the replace plate. Replace plate's surface is badly exposed to the pressure plate therefore secondary damage going to occur.

c) Directional deformation of the Clutch plate

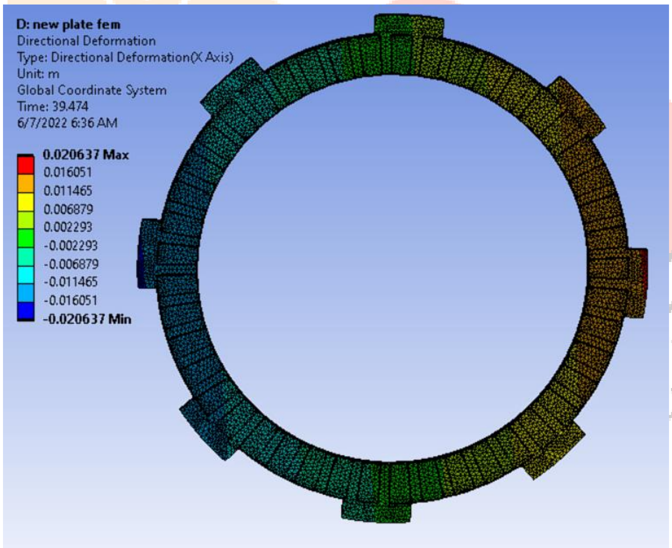


Figure. It show the Directional deformation of new clutch plate.

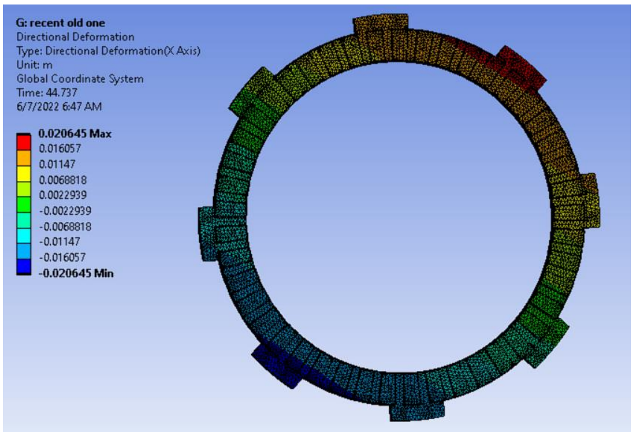


Figure. It show the Directional deformation of less used clutch plate.

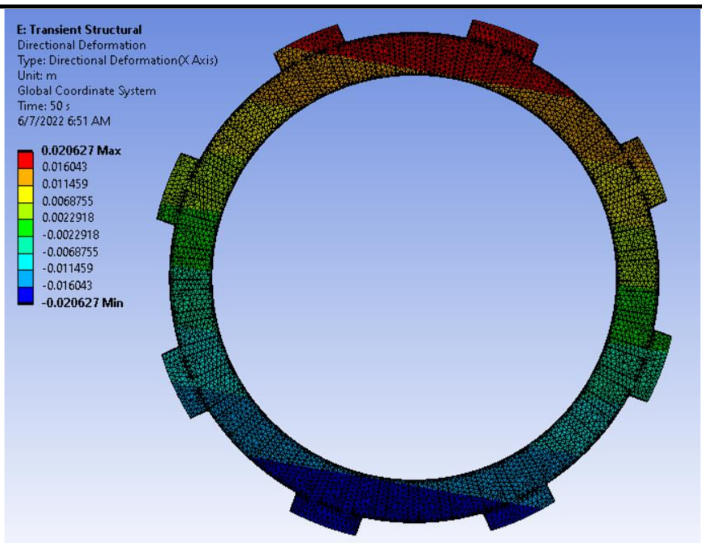


Figure. It show the Directional deformation of replaced clutch plate.

Above results shows the direction deformation in the clutch plate. As we find out that directional deformation is very high in the heist wear plate and it affect the plate live very rapid.

d) Shear Stress Distribution on clutch plate

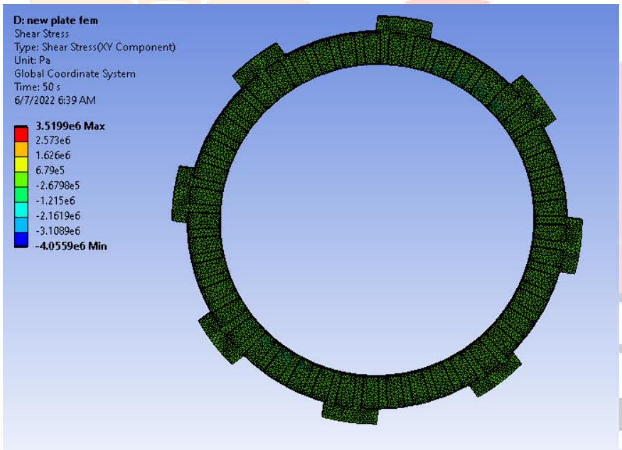


Figure. It show the Shear stress distribution on new clutch plate.

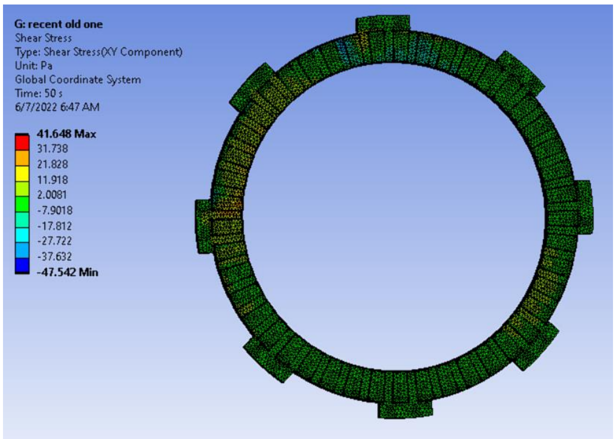


Figure. It show the Shear stress distribution on new clutch plate.

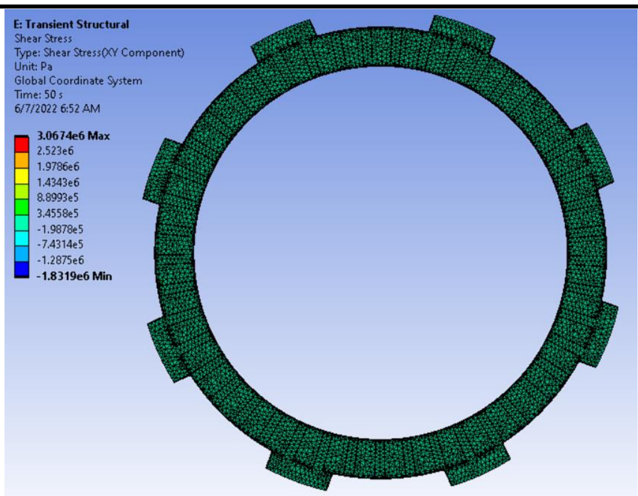


Figure. It show the Shear stress distribution on replaced clutch plate.

e) Fiction Force Distribution

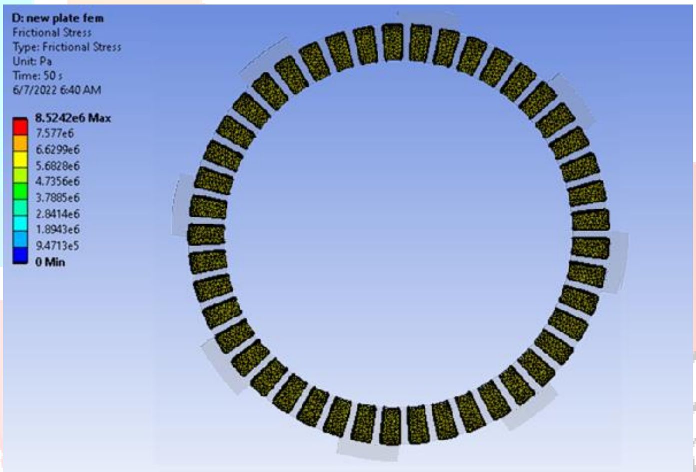


Figure. It show the Friction force distribution on new clutch plate.

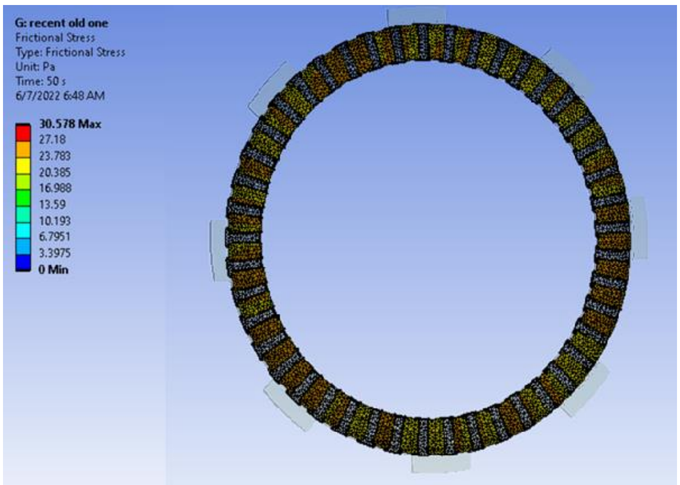


Figure. It show the Fiction stress distribution less used clutch plate.

Figure. It show the Friction stress distribution on replaced clutch plate.

CONCLUSIONS AND FUTURE SCOPE

As we find out one relation between the life and heat generation in clutch plate so we produce heat in various clutch plate and find the stress distribution. From the result we got the new plate has less heat generation than replaced one and more heat generation to the just use one it shows new plate is going to loss there life very rapid but after some use its friction reduce and life increase (heat loss also decrease) and when the plate is going to replace its surface area increase and frictional contact also increase due to that heat generation in plate also increase.

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