# Design and Analysis of Clutch Plate for Automatic Single Plate Clutch

**Ravikiran M. Tate[1] S. H. Sarje[2]**
[1,2]Department of Mechanical Engineering
[1,2]JSPM's ICOER Wagholi, Pune

*Abstract*— Conventional transmission system using single plate clutch has to perform 15 operations to shift from low speed to high speed, out of the 10 operations are clutch operations. Hence making clutch operations automatic will reduce human effort. The auto-disengagement single clutch employs only one set of compression springs instead of the usual two sets, with this arrangement it is possible to reduce the weights of the centrifugal members. This arrangement keeps the clutch in normally disengaged condition unlike the conventional clutch that is in engaged condition and has to be disengaged by manual Lever. In transmitting power from engine to gearbox, Clutch plate plays an important role. So in this paper we designed a single plate clutch by using empirical formulae. By using CATIA V5 we have created a model of single plate clutch and then imported in ANSYS workbench for analysis. We have conducted static structural analysis of clutch base and its friction plate with lining material as FTL 097. The results are compared for the maximum deformation and stresses.

***Key words:*** ANSYS, Auto-disengagement, CATIA V5, Deformation, FTL 097, Stresses

## I. Introduction

Clutch is a mechanical device which is used to transmit the power of a source i.e. engine to the remaining parts of the power transmitting system at the will of an operator. The clutch can engage or disengage the diving shaft from driven shaft in order to transmit or stop the motion. An automotive clutch can permit the engine to run without stopping the vehicle. This is desirable when the vehicle is to be started or stopped, or when gear shifts are needed. The selection of a clutch is depends upon orientation, speed, material and torque produced. When vehicle is started from standstill clutch is engaged to transfer torque to the transmission; and when vehicle is in motion clutch is first disengaged of the drive to allow for gear selection and then again engaged smoothly to power the vehicle. [2] Generally there are two types of clutches based on type of contact [1]

- Positive Clutch
- Friction Clutch

Positive clutch transmits the power from input shaft to output shaft by means of jaws or teeth. Friction clutch transmits the motion from input to output shaft though friction material.

Positive clutches are not desirable at high speed so the friction clutches are generally used in automobile application.[3]

### A. *Desirable Properties of Friction Material*

- High coefficient of friction
- High resistance to wear
- Friction value should be constant for a wide range of pressure and temperature
- Good shear strength in order to transmit the friction force to structure
- It should posses good thermal conductivity, High heat capacity
- It should be resistance to environment (Dust, Moisture)[4]

## II. Material Used for Friction Liner

The Common Facing material used

### A. *Leather:*

Dry leather on iron has coefficient in friction of 0.27.

### B. *Cork:*

Cork or dry steel or iron has coefficient of friction of about 0.4 but there cannot be used at high temperature.

### C. *Fabric:*

Good quality fabric materials have coefficient of friction of about 0.4 but they cannot be used at high temperature.

### D. *Asbestos:*

Asbestos facing have coefficient of friction of about 0.2. However it has got anti heat characteristics.

### E. *Reybestos & Ferrodo:*

These have a coefficient of friction of about 0.35 and are most suitable as friction facings.

In Our project the friction liner material is taken from the Friction Technology Ltd. Catalogue. Now a day's FTL097 is used for the brake pads in the industries. FTL097 has a high friction coefficient up to 0.38±0.05. This is combined with an excellent resistance to fade and wear. Its high performance characteristics are particularly suited to severe duty applications. This material although not intended to operate in oil is not physically damaged by moderate oil contamination.

### F. *FTL097:*

Fig. 1: FFTL097

1) *Physical Properties:*
- Density g/cm 1.94 – 1.99
- Hardness (SHORE-D) 87 - 90
- Acetone extraction < 2%
- Ignition loss 35-37%

2) *Friction Properties:*
- Friction coefficient (dynamic)µ 0.38± 0.05
- Wear rate (@ 79N, 7m/s)F.A.S.T 35-40mm3 /Kwh

 

*3) F.A.S.T. test conditions (Fade temperature)*

The FAST is a 90 minute test at constant pressure and velocity, which reports response of friction coefficient vs temperature. These are the maximum temperatures resistance before material lost coefficient.

| | | | |
|---|---|---|---|
| F=79N | v=7m/s | t=90min | <250ºC |
| F=100N | v=7m/s | t=90min | <300ºC |
| F=100N | v=11m/s | t=80min | <355ºC |

*4) Recommended Operating Temperatures (max):*

- Continuous operation 250ºC
- Intermittent operation 350 ºC

*5) Adhesives:*

The use of any well-known thermosetting adhesive is recommended.

*6) Rubbing Surfaces:*

Good quality, fine grained pearlitic cast iron with Brinell hardness of 150-200 is recommended

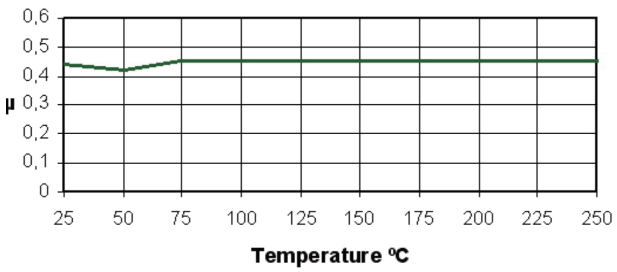


Fig. 2: Temperature Vs Coefficient of friction (μ)

## III. Clutch Plate

Clutch plates are made of cast iron or high carbon steels with a splined hub and a round metal plate lined with friction lining material.

### *A. Design*

Motor Details

Single Phase AC Motor 230 Volt, 50Hz 0.5 Amps,

Power = 0.125Hp = 93.25 watt

Speed = 1500 rpm

Tdesign = $0.742 \times 10^3$ N-mm

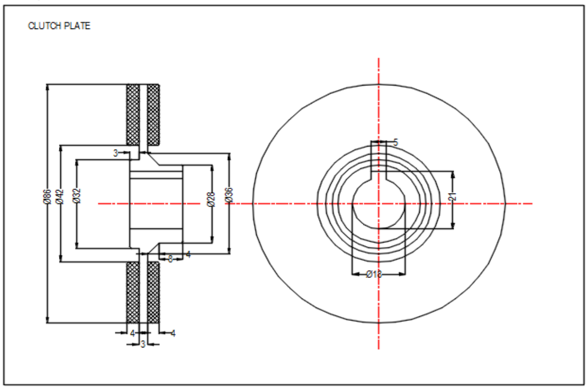


Fig. 3: 2D Drawing of Clutch Plate

Theoretical design of Clutch Plate base

Material selection[5]

| Designation | Ultimate Tensile Strength N/mm² | Yield Strength N/mm² |
|---|---|---|
| EN24 | 800 | 680 |

As Per ASME Code;

$fs_{max} = 108\ N/mm^2$

Where, fs is Torsional Shear Stress in N/mm²

Check for torsional shear failure:-

$$T = (\pi/16) \times fsact \times \frac{(D_0^4 - D_i^4)}{(D_0)}$$

$$0.742 \times 10^3 = (\pi/16) \times fsact \times \frac{(28^4 - 18^4)}{(28)}$$

$fsact = 0.21\ N/mm^2$

Where fsact is Actual Torsional Shear Stress in N/mm²

T is Torque applied in N-mm

As; $fs_{act} < fs_{all}$

Where $fs_{all}$ is allowable Torsional shear stress in N/mm²

Clutch base is safe under torsional load

### *B. Structural Analysis of Clutch Base*

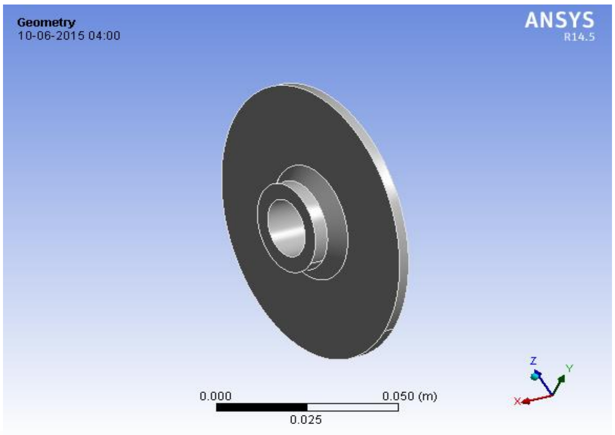


Fig. 4: Importing of Clutch Base using into

*1) ANSYS Workbench*

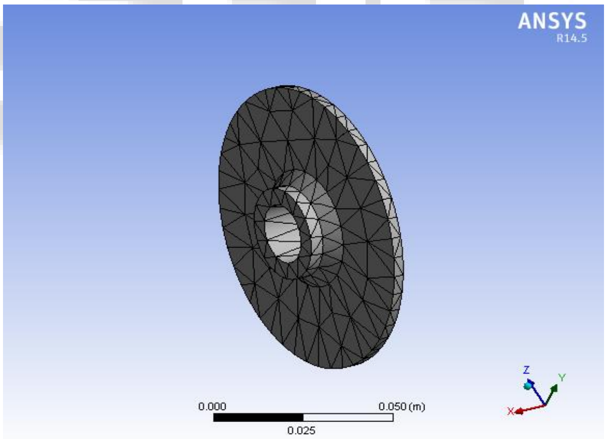


Fig. 5: Meshing of Clutch Base

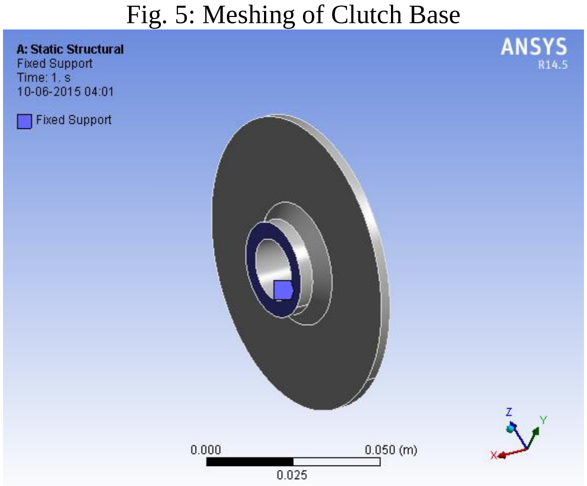


Fig. 6: Boundary Condition for Single Plate Clutch

 

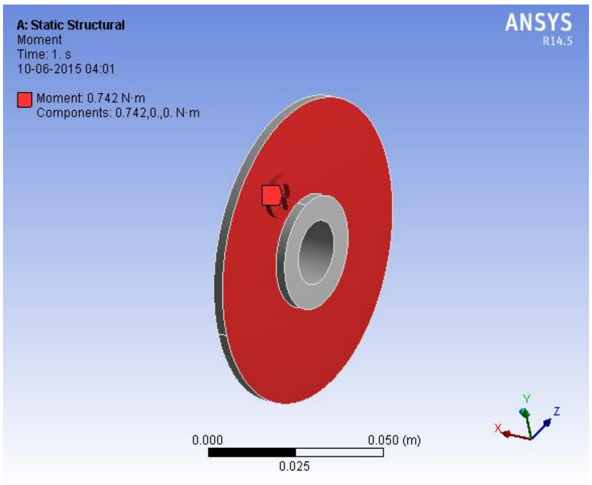


Fig. 7: Application of Torque on Clutch Base (Torque = 0.742 N-m)

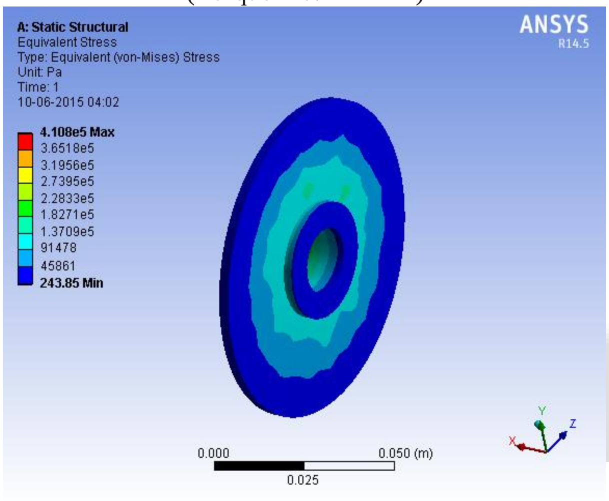


Fig. 8: Result of Clutch Base

### C. *Structural analysis of Friction Liner Plate*

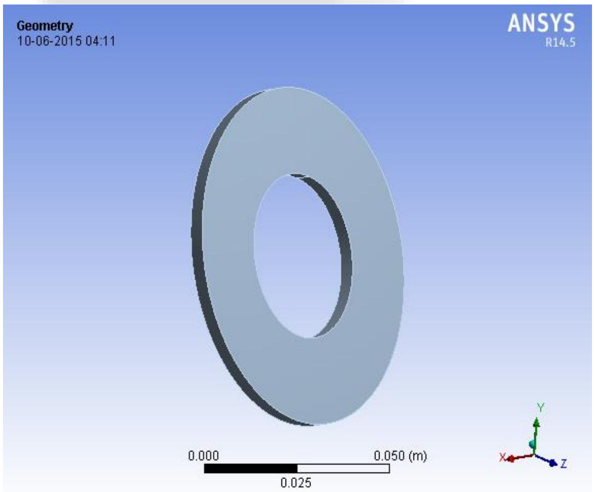


Fig. 9: Importing of Friction liner Plate using into

1) *ANSYS Workbench*

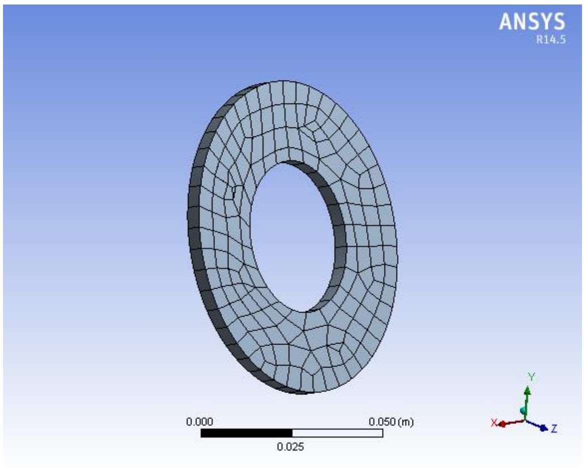


Fig. 10: Meshing of Friction liner Plate

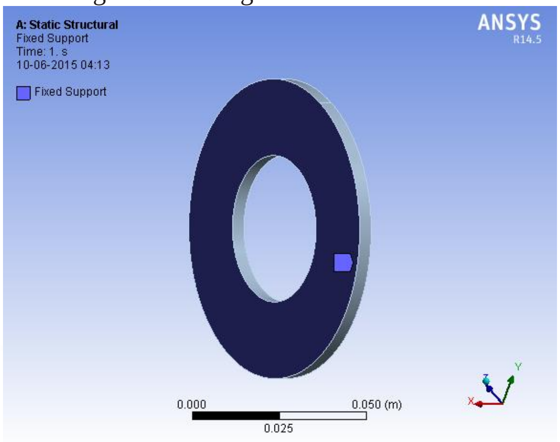


Fig. 11: Boundary Condition for Friction Liner Plate

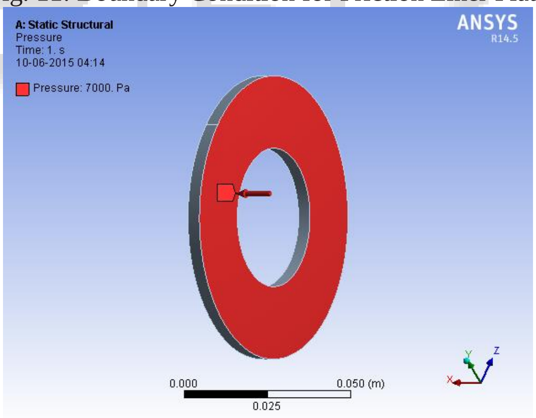


Fig. 12: Application of Load (Pressure=7 KPa)

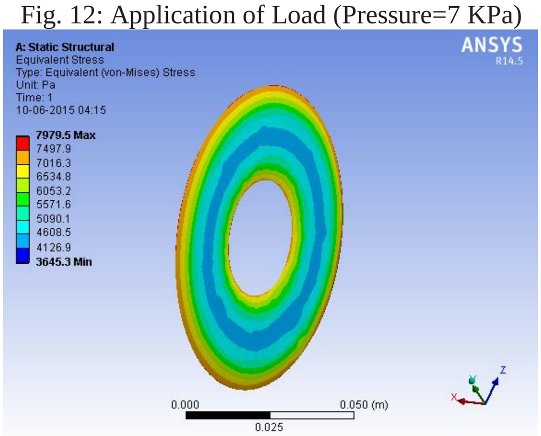


Fig. 13: Von-Mises Stresses in Friction Liner Plate

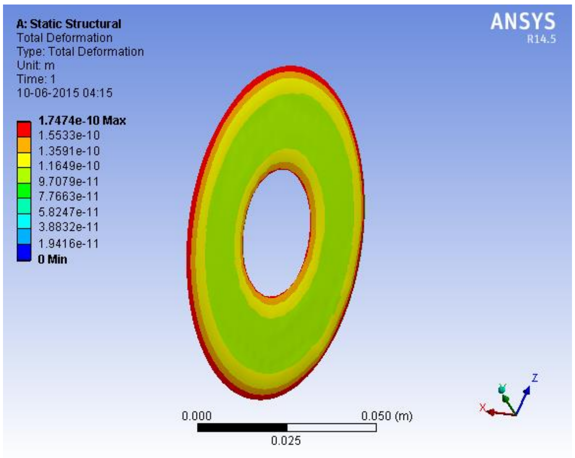

Fig. 14: Total Deformation of Friction Liner Plate

## IV. RESULT

| Part Name | Maximum stress N/mm$^2$ | Maximum deformation Mm | Result |
|---|---|---|---|
| Clutch base | 4.10 | - | Safe |
| Liner | 0.07979 | 1.7 x $10^{-10}$ | Safe |
| Face counter reduction | 11.08 | $10^{-7}$ | |

## V. CONCLUSION

In the above work we have modeled a single plate clutch from theoretical calculation and the 3D drafting is done through CATIA V5.The clutch base plate and Friction liner plate are analyzed through ANSYS. The friction material is taken as FTL097 and it is found that Maximum stress in all conditions is well below the allowable limit hence both parts are safe, Negligible deformation is seen in case of clutch liner thereby suitable for clutch lining as it will result in lesser wear.

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