Structural Analysis Of Multi-Plate Clutch

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***Abstract*— In this paper, we design a multi plate clutch by using empirical formulas. A 2D drawing is drafted for multi plate clutch from the calculations & a 3D model is created in the modeling Software Pro/E for Automobile Applications. We have conducted, structural analysis by varying the friction surfaces material. By extracting the results Comparison is done for both materials to validate better lining material for multi plate clutch To find out which material is best for the lining of friction surfaces. Analysis is done in ANSYS software.**

***Keywords*— ANSYS, Cork, Copper, Stress, Strain.**

I. Introduction

Clutch is a mechanism for transmitting rotation, which can be engaged and disengaged. Clutches are useful in devices that have two rotating shafts. In these devices, one shaft is typically driven by a motor or pulley, and the other shaft drives another device. Let us take an instance where one shaft is driven by a motor and the other drives a drill chuck. The clutch connects the two shafts so that they can either be locked together and spin at the same speed (engaged), or be decoupled and spin at different speeds (disengaged). Depending on the orientation, speeds, material, torque produced and finally the use of the whole device, different kinds of clutches are used. The clutch in itself is a mechanism, which employs different configurations.

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II. FRICTION CLUTCH

The friction clutch is an important component of any automotive machine. It is a link between engine and transmission system which conducts power, in form of torque, from engine to the gear assembly. When vehicle is started from standstill clutch is engagedtotransfer 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.

Desirable properties for friction materials for clutches:

- The two materials in contact must have a high coefficient of friction.
- The materials in contact must resist wear effects, such as scoring, galling, and ablation.
- The friction value should be constant over a range of temperatures and pressures
- The materials should be resistant to the environment (moisture, dust, pressure)
- The materials should possess good thermal properties, high heat capacity, good thermal conductivity, withstand high temperatures
- Able to withstand high contact pressures
- Good shear strength to transferred friction forces to structure

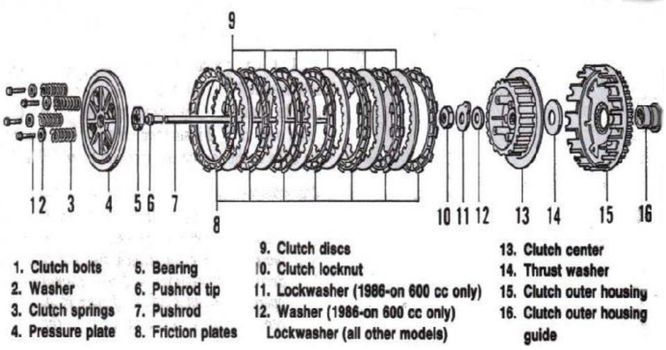


Fig. 1: De-Assembly of Multi-Plate Clutch

III. PROPERTIES OF MATERIALS USED FOR CLUTCHES

Note: These properties are very general in nature and should not beusedfordetail design. Suppliersinformation should be used for important work.

Material Combination	Coefficient of Friction		Temp.(max)	Pressure (Max)
	Wet	Dry	Deg.C	MPa
Cork/Cast Iron-Steel	0,15-0,25	0,3-0,5	100	0,1
Carbon-graphite/Cast Iron- Steel	0,05-0,1	0,25	500	2.1
Kelvar/Cast Iron-Steel	0,05-0,1	0,35	325	3,0

IV. SPECIFICATIONS

Power = 14.8438 BHP @ 9000 rpm

Torque = 12.45 N-m = 12.45* 10^3 N-mm.

@ 6500rpm

Material used is pressed asbestos on cast iron or steel μ = 0.3

Maximum operating temperature °C = 150 – 250

Maximum pressure N/mm^2 = 0.4

r_1 and r_2 outer and inner radius of friction faces

r_1 =109mm and r_2 = 90 mm

n = no of pairs of contact surfaces

$n = n_1 + n_2 - 1$

Wheren_1 andn_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:

$R = 2/3[(r_1^3-r_2^3)/(r_1^2-r_2^{2)}]$

$= 2/3[(109^3)-(91^3)/ (109^2)-(91^2)]$

= 2/3[541458/3600]

= 2/3[150.405]

=100.27mm.

For uniform wear R = $\frac{r_1+r_2}{2}$ = [(109+91)/2]= 100mm.

A. 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.

We Know That T = 12.45*10^3=8*0.3*W*100.27.

W = 12.45*10^3/8*0.3*100.27. W= 51.735N.

$$P = \frac{W}{\Pi(r_1^2 - r_2^2)} = \frac{W}{\pi(109^2 - 91^2)}$$

P= 4.5743X10^{-3} N/mm^2

B. 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 clutch.

T = μ W R

We Know That

$T = 12.45 \times 10^3\ N - mm,\ R = 100.27,\ \mu = 0.3$

Bysubstitutingallthesevaluesweget

W=$12.45 \times 10^3 = 0.3 \times W \times 100.27 = 413.8825$N

Pressure P

$$P = \frac{W}{\Pi(r_1^2 - r_2^2)} = P = \frac{413.8825}{\Pi(109^2 - 91^2)} = \frac{413.8825}{11309.73}$$

P= 0.03659 N/mm^2.

C. Considering uniform axial wear:

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

Axial force required to engage the clutch

$W = 2\pi C (r_1-r_2)$

Mean radius of the friction surfaces.

$$R = \frac{109+91}{2} = 100$$

Torque transmitted

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

$$12.45 \times 10^{3} = 8 \times 0.3 \times W \times 100 = 51.875N$$

The intensity of pressure is maximum at the inner radius (r_2) of the friction or contact surface.

Equation may be written as $P_{max} \times r_2 = C$

We know that total force acting on the friction surface.

$$C = \frac{W}{2\Pi(r_1 - r_2)} = \frac{51.875}{2\Pi(109-91)} = 0.4586N - mm$$

$$P_{max} = \frac{C}{r_2} = \frac{0.4586}{91} = 0.0050404\text{Mpa}$$

The intensity of pressure is minimum at the outer radius (r_1) of the friction or contact surface

Equation may be written as $P_{min} \times r_1 = C$

$$P_{\min} = \frac{C}{r_2} = \frac{0.4586}{109} = 0.0042073N - mm$$

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

$$P_{avg} = \frac{\text{Total Force on Friction Surfaces}}{\text{Cross-sectional Area of friction surfaces}}$$

$$P_{avg} = \frac{W}{\Pi(r_1{}^2 - r_2{}^2)} = P = \frac{51.875}{\Pi(109^2 - 91^2)} = 0.004586N - mm$$

D. 2D DRAWINGS:

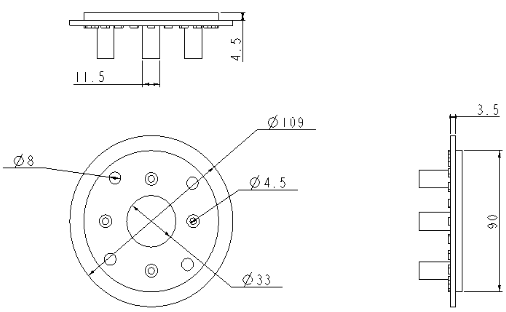


Fig 2. Base Plate

E. DOUBLE PLATE:

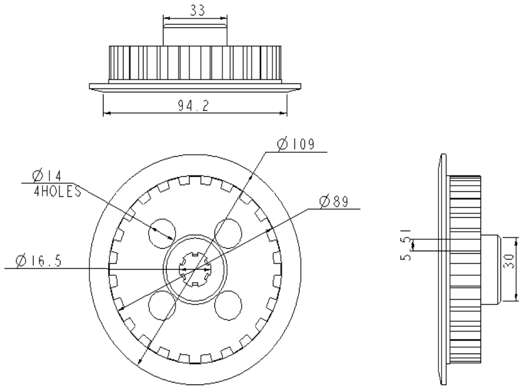


Fig 3. A 2D-Part of Double Plate.

F. FRICTION PLATE:

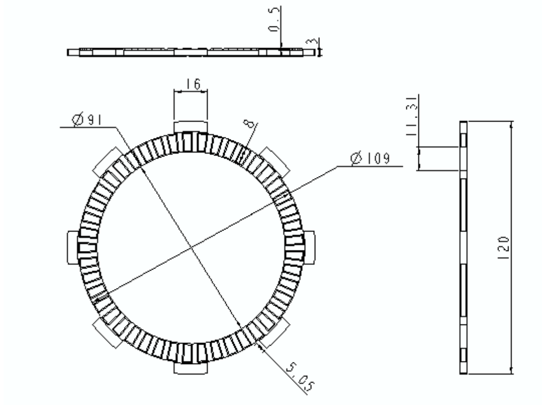
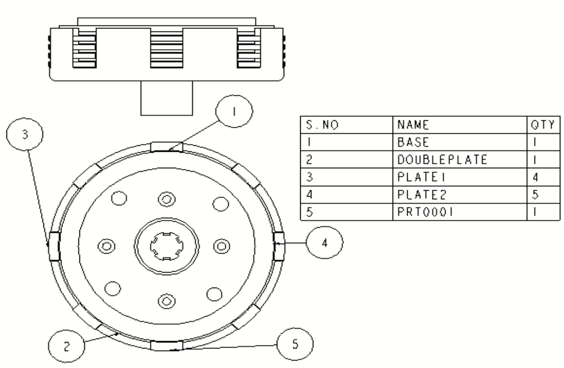


Fig 4. Friction Plate.

G. ASSEMBLY:



S.NO	NAME	QTY
1	BASE	1
2	DOUBLEPLATE	1
3	PLATE1	4
4	PLATE2	5
5	PRT0001	1

H. EXPLODED VIEW OF MULTI-PLATE CLUTCH:

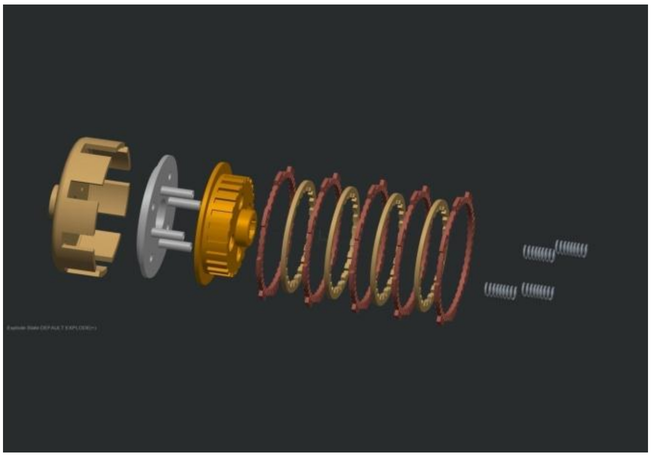


Fig 6: Multi-Plate Clutch Exploded View

V. STRUCTURAL ANALYSIS FOR FRICTION PLATE

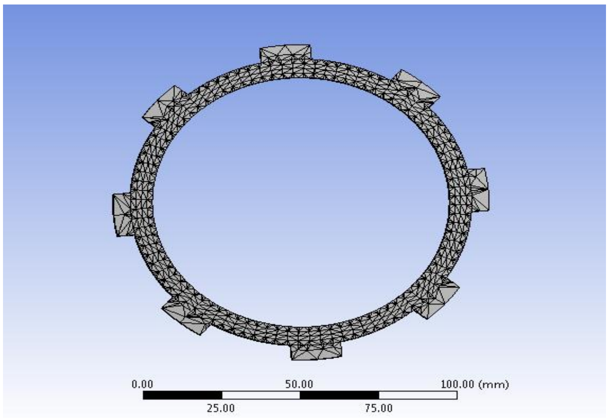


Fig 7**:** Importing of Multi-Plate Clutch using into ANSYS WORKBENCH

i. LOADS:

Pressure – 0.0050404Mpa

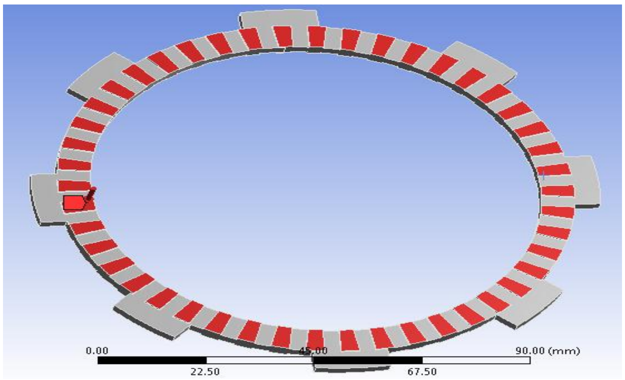


Fig 8. Loads Applied On Multi-Plate Clutch.

ii. Material Properties:

TABLE 2
Materials used in multi-plate clutch.

S.No	Materials	Density (Kg/m$^{3)}$	Youngs Modulus (Mpa)	Poissons Ratio	Yield Stress (Mpa)
1	CORK	180	32	0.25	1.4
2	COPPER	8300	135*10^{3}	0.35	510

VI. RESULTS

A. FRICTION MATERIAL: CORK

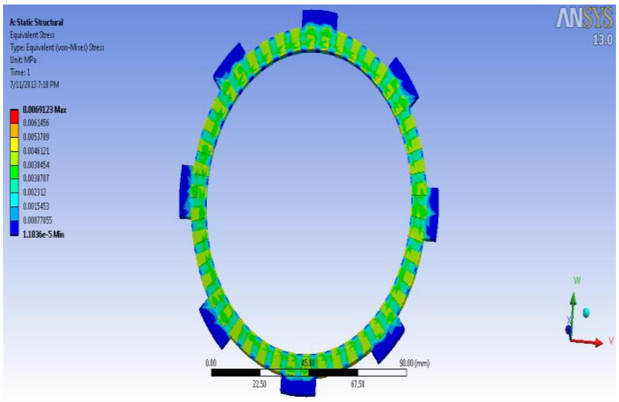


Fig 9. Results of Friction Plate using CORK as Friction Material Obtained from ANSYS WORKBENCH.

B. FRICTION MATERIAL: COPPER

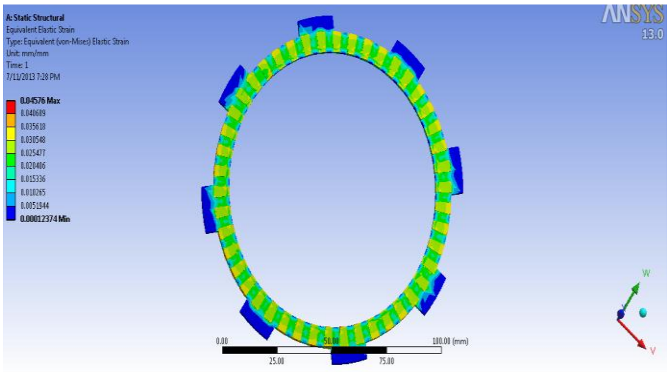


Fig10. Results of Friction Plate using COPPER as Friction Material Obtained from ANSYS WORKBENCH.

Material	Von-Mises Stress (Mpa)	Normal Stress (Mpa)	Max. Shear Stress (Mpa)	Von-Mises Strain	Total Deformation (mm)
CORK	0.0067	0.00388	0.0038422	0.00021	0.00041
COPPER	0.0061	0.00351	0.003498	$4.533e^{-8}$	$1.1511e^{-7}$

(a). Results from Analytical Analysis.

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 CREOPro/Engineer software.Structural analysis is done on the friction plates to verify the strength.Friction materials used are Cork and Powder Metal.By observing the analysis results, the stress and strain values for copper powder metal are less than Cork respective values. So we expected that for multi plate clutches using powder metal as friction material is advantageous than using cork as friction material.

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