Analysis of Multidisc Clutch Using FEA

Ganesh Raut[#1], Anil Manjare[#2], P Bhaskar[#3]
[#123]Department of School of Mechanical and Building sciences, M. Tech Automotive Division,
VIT University, TamilNadu-632001, India.

***Abstract*—Multi plate clutch is one of the important part in the power transmission systems. Good design of clutch provides better engine performance. Multi plate clutch is most widely used in racing cars and heavy duty vehicle where high torque transmission required and limited space is available. In this paper we designed a multi plate clutch by using empirical formulae. A model of multi plate clutch has been generated in CATIA V5 and then imported in ANSYS workbench for Automobile Applications. We have conducted structural analysis by varying the friction surfaces material and keeping base material aluminium same. By seeing the results, Comparison is done for both materials to validate better lining material for multi plate clutch by doing analysis on clutch with help of ANSYS Workbench software for find out which material is best for the lining of friction surfaces.**

***Keywords*— ANSYS Workbench, SFBU, LO31, Stress, strain.**

I. INTRODUCTION

The clutch is a mechanical device, which is used to connect or disconnects the source of power from the remaining parts of the power transmission system at the will of operator. The clutch can connect or disconnect the driving shaft and driven shaft. An automotive clutch can permit the engine to run without driving the car. This is desirable when the engine is to be started or stopped, or when the gears to be shifted. Clutch is a mechanism for transmitting rotation, which can be engaged and disengaged. 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. 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 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. Generally there are two types of clutches based on type of contact

- Positive clutch
- Friction clutch

Multi plate clutch comes under the category of friction clutch. Multi plate clutch is an extension of single plate type where the number of friction and metal plates is increased. The increases in the number of friction surfaces obviously increase capacity of clutch to transmit torque, the size remaining fixed. Alternatively, the overall diameter of clutch is reduced for the same torque transmission as a single plate clutch. This type of clutch is, therefore used in some heavy transport vehicles and racing cars where high torque is to be transmitted. Besides, this finds application in case of scooters and motorcycles, where space available is limited

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.

II. MATERIAL USED FOR CLUTCH

A.Friction material SF-BU

SF-BU is a high performance, high friction, non-metallic composite material containing a high percentage of aramid fibre. It can be considered an alternative to sintered metallic materials and offers many advantages, it will with stand high energy inputs, is suitable for both dry and oil-immersed applications. It is not abrasive to the counter material, is silent in operation, it will with stand high pressures. The wear rate is low even at high temperatures, is available in thicknesses from 0.6mm to 5mm. Similar to SF001 but even higher Kevlar composition, in order to enhance friction properties. Applications: heavy vehicle clutches, clutch buttons, trucks clutches, friction gaskets, vehicle clutches.

B.Friction material LO31

LO31 is a rigid moulded friction material, whose main characteristics are the low dynamic friction coefficient having the lowest friction. It is composed basically of resins as a link

system with frictional modifier agents. This material has good mechanical properties.
Applications: industrial clutches, continuous brakes, callipers for industrial purpose.

TABLEI
Materials used in multi-plate clutch.

Sr. No.	Materials	Density (Kg/m^3)	Young's modulus(Mpa)	Poisson ratio	Tensile strength (Mpa)
1	LO31	1940	11925	0.23	37
2	SFBU	1250	7260	0.5	70
3	Aluminium 6061	2700	68900	0.33	276

Material combination	Coefficient of friction	Temp. (Max) C
LO31/ Aluminium	0.23	150
SFBU/ Aluminium	0.50	325

III. SPECIFICATION OF CLUTCH

Torque = 150 Nm at speed N = 750 rpm
r_1 and r_2 outer and inner radius of friction faces
r_1 =75mm and r_2 = 45 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.
μ = coefficient of friction.
T = Transmitting torque.
w = Total operating force.
P = Intensity of pressure at radius r (N/mm^2).
Calculating operating force and operating average pressure by using uniform wear theory as follows

A.For SFBU friction material

$R = (r_1+r_2)/2$

$= (75+45)/2$

$= 60$ mm

$= 0.060$m

Required operating force:

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

$120 = 8\times0.5\times w\times0.060$

$w = 120 \div (8\times0.5\times0.060)$

$w = 500$N

Average operating pressure:

$w = (2\times\pi\times P\times r_2)\times(r_1-r_2)$

$500 = (2\times\pi\times p\times45)\times(75-45)$

P= 0.0589 MPa

B.For LO31 friction material

Required operating force:

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

$120 = 8\times0.23\times w\times0.060$

$w = 120 \div (8\times0.23\times0.060)$

$w = 1086.95$ N

Average operating pressure:

$w = (2\times\pi\times P\times r_2)\times(r_1-r_2)$

$1086.95 = (2\times\pi\times P\times45)\times(75-45)$

P = 0.1281 MPa.

C. 3d drawing of clutch

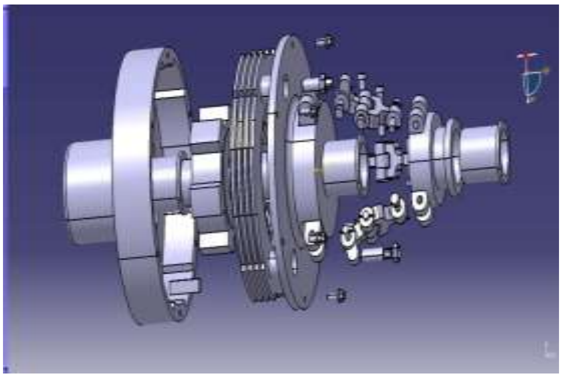

Fig. 1. Exploded view of multi-plate clutch

D.2d drawing of clutch

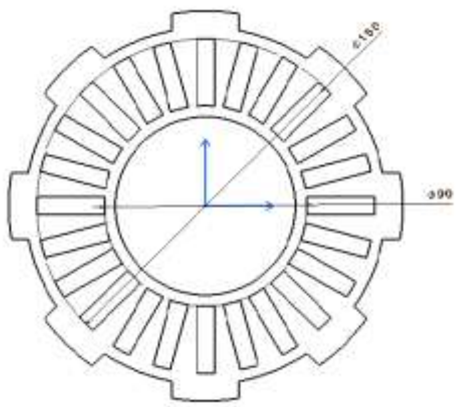

Fig.2 drafting of multi plate clutch

IV. STRUCTURAL ANALYSIS FOR FRICTION PLATE

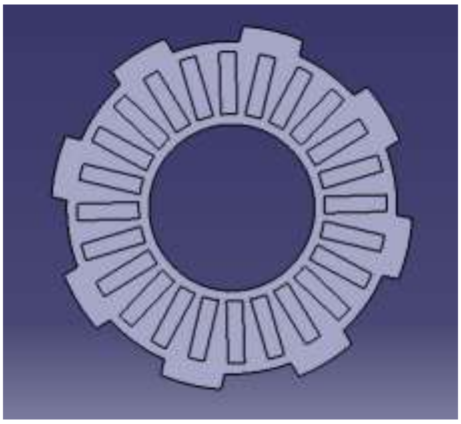

Fig. 3.Clutch discussed for analysis of Multi-Plate Clutch

A.Friction material: SF-BU.

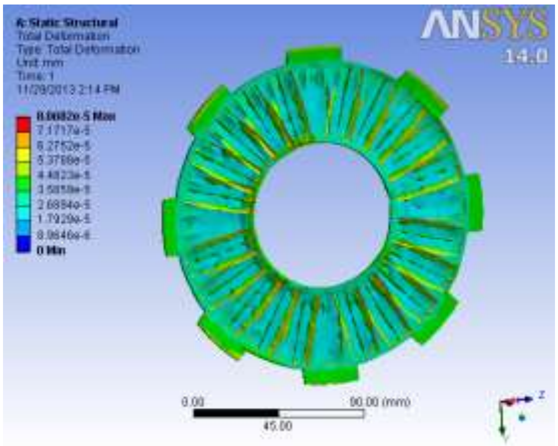

Fig. 4. Total deformation of Friction Plate using SF-BU as friction Material Obtained from Ansys workbench.

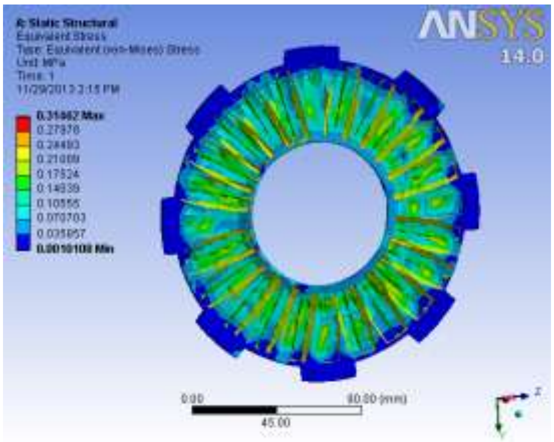

Fig. 5.Von-Mises Stress results of friction plate using SF-BU as friction material obtained from ANSYS workbench.

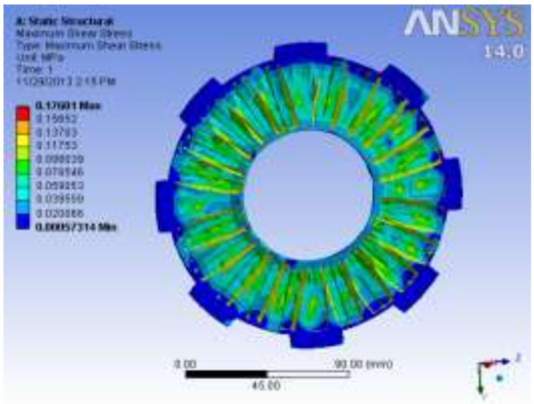

Fig. 6 Shear Stress results of friction plate using SF-BU as friction Material obtained from ANSYS workbench.

B.Friction material: LO31

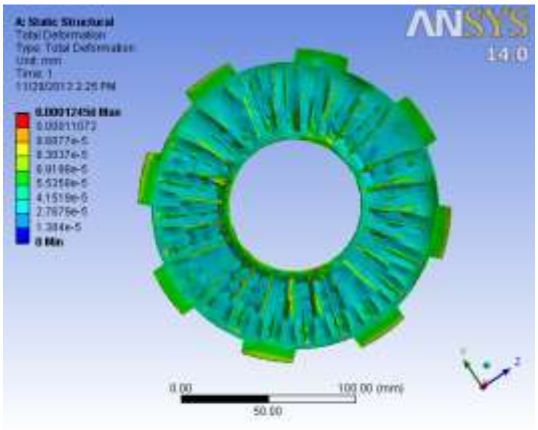

Fig. 7. Total deformation results of friction plate using LO31 as friction material obtained from ANSYS workbench.

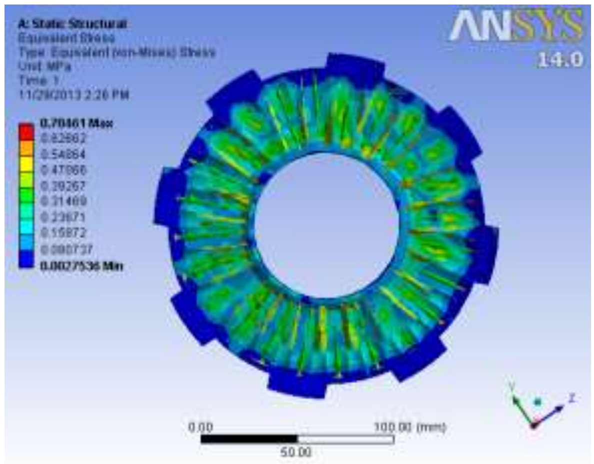

Fig. 8.Von-Mises Stress results of friction plate using LO31 as friction material obtained from ANSYS workbench.

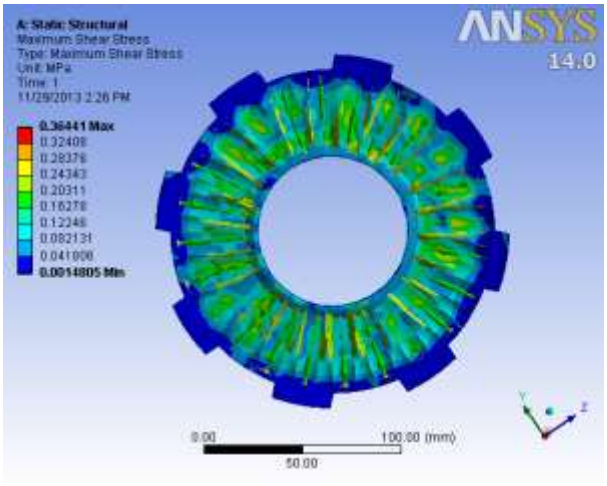

Fig. 9. Shear Stress results of friction plate usingLO31 as friction material obtained from ANSYS workbench.

TABLE II
Result from analysis

Material	Von-Mises Stress (Mpa)	Max. Shear Stress(Mpa)	Total Deformation (mm)
SF-BU	0.31462	0.17601	8.0682×10^{-5}
LO31	0.70461	0.36441	12.456×10^{-5}

V. CONCLUSION

In our project we have designed a multi plate clutch using theoretical calculations. 2-D drawings are drafted from the calculations. 3-D model of the multi plate clutch parts and assembly are done in CATIA V5 software. Structural analysis is done on the friction plates to verify the strength. Friction materials used are LO31and hybrid SF-BU. By observing the analysis results, the maximum shear stress, Von-Mises stress and total deformation values for hybrid SF-BU are less than LO31 respective values. So we expected that for multi plate clutches using as hybrid SF-BU friction material is advantageous than using LO31 as friction material.

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