Static and Dynamic Analysis of Composite Clutch Plate

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Abstract— A Clutch is a machine member used to connect the driving shaft to a driven shaft, so that the driven shaft may be started or stopped at will, without stopping the driving shaft. A clutch thus provides an interruptible connection between two rotating shafts. The present used material for friction disc is Cast Iron and aluminum alloys. In this thesis analysis is performed using composite materials. The composite materials are considered due to their high strength to weight ratio. In this thesis composite materials CFRP, GFRP, Boron Epoxy and HT graphite Composite are taken. A single plate clutch is designed and modelled using Solid works. Static analysis and Dynamic analysis is done on ANSYS 12.0 to determine stresses and deformations using materials Grey Cast Iron, Boron Epoxy and HT graphite Composite. Theoretical calculations are also done to find out weight saving, strength to weight ratio, stress, strain and displacement.

Key words: FEM, ANSYS, Solid Works, HT Graphite, Static, Stress, Deformation, Composite, Clutch, Epoxy, Strain

I. INTRODUCTION

A clutch is that part of an engine which engages or disengages power from the engine crankshaft to transmission. A clutch is a mechanism which turns on or off power to rear wheel. A clutch is made of clutch assembly which includes clutch plate, clutch basket, clutch hub, pressure plate, clutch springs, lever, clutch cable, diaphragm spring, friction facings, release bearing. A friction clutch works on the principle of creating contact due to friction. The pressure plate applies pressure on the clutch plate which is sandwiched between flywheel and the pressure plate. The engagement and disengagement occurs when the clutch pedal is pressed. The driver can shift the gears easily and re-engage the clutch. The common clutch plate materials used are cast iron and aluminium alloys. In this analysis composites are used as clutch plate materials. The analysis is performed on ANSYS 12.0 and stress, strain, displacement are found. Also weight saving, weight reduction, and Strength to weight ratio are calculated.

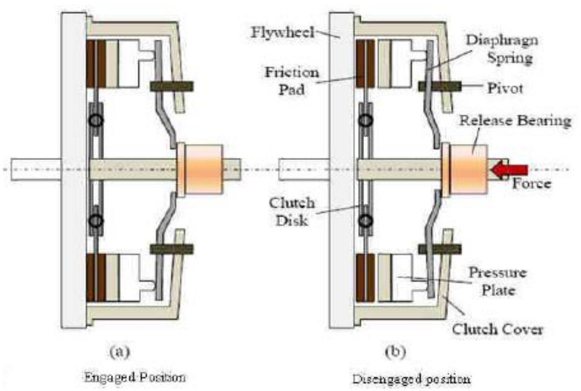

Fig. 1: Engagement and Disengagement of clutch plate

The clutch plate consists of two sets of facings of friction material mounted on steel cushion springs. The facings and the waved cushion springs are riveted to a spring base disc and spring retainer plate. The waves of the cushion springs compress slightly as the clutch engages and thus provide some cushioning effect. The base disc and the spring retainer plate are slotted for inserting the torsion springs. These torsion springs contact the hub flange that fits between the spring retainer plate and the disc. The principle of this device is that the driven plate is not rigidly connected to the hub of the driven shaft but left free rotationally thereon and is connected through a number of small spring's blocks. As such, these torsion springs serve to transmit the twisting force applied to the facings, to the splined hub. The spring action serves to reduce tensional vibrations and shocks between the engine and the transmission during clutch operation. By this arrangement, certain tensional vibrations of the crankshaft that have given rise to noise in the gear box are damped out and noise is eliminated.

II. MATERIALS USED FOR CLUTCH

There are five materials used for clutch plate. They are cast iron, carbon fiber reinforced polymer, glass fiber reinforced polymer, boron epoxy and HT Graphite.

Dimensions	Values
Outer Radii	114 Mm
Inner Radii	64 Mm
Pressure Applied	26000 Nm^{-2}

Table 1: Dimensions of the Plate

Properties	Value
Young's Modulus	120000 Nmm^{-2}
Poisson's Ratio	0.29
Density	7800 Kgm^{-3}

Table 2: Properties Of Cast Iron

	CFRP	GFRP	Boron Epoxy	HT Graphite
Ex(Nmm^{-2})	181000	38600	250000	221000
E_y(Nmm^{-2})	10300	8270	14226	12576
E_z(Nmm^{-2})	10300	8270	14226	12576
G_{xy}(Nmm^{-2})	7170	4140	9903	8750
G_{yz}(Nmm^{-2})	5160	2980	7127	6300
G_{zx}(Nmm^{-2})	7170	4140	9903	8750
PR_{xy}	0.28	0.26	0.28	0.28
PR_{yz}	0.30	0.43	0.30	0.30
PRzx	0.28	0.26	0.28	0.28
Density (kgm^{-3})	1600	1800	1900	1750

Table 3: Properties of Composites Tested

III. Analysing in ANSYS

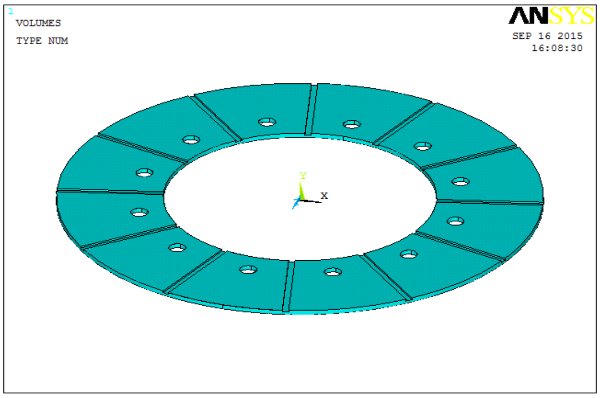

Fig. 2: Solid Model for Analysing Cast Iron Material

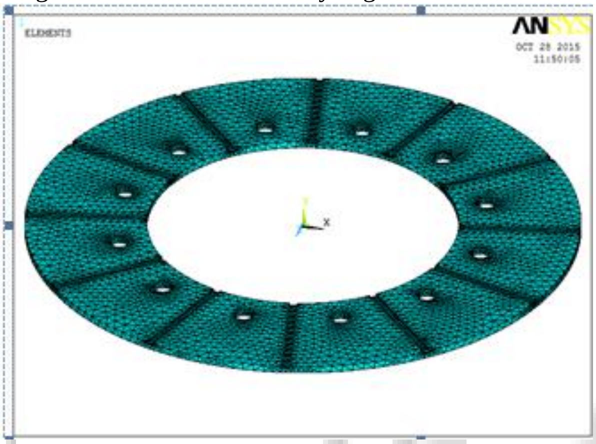

Fig. 3: Meshing of the Solid Model

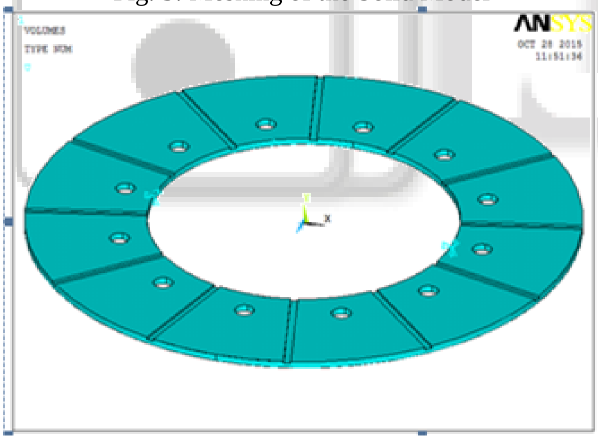

Fig. 4: Applying Boundary Conditions

IV. Contour Plot for Cast Iron

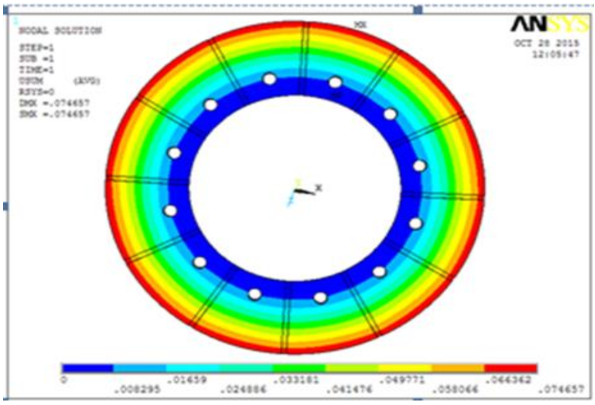

Fig. 5: Displacement

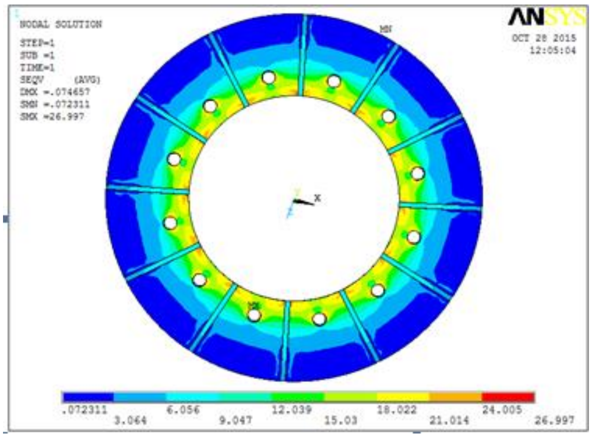

Fig. 6: Stress

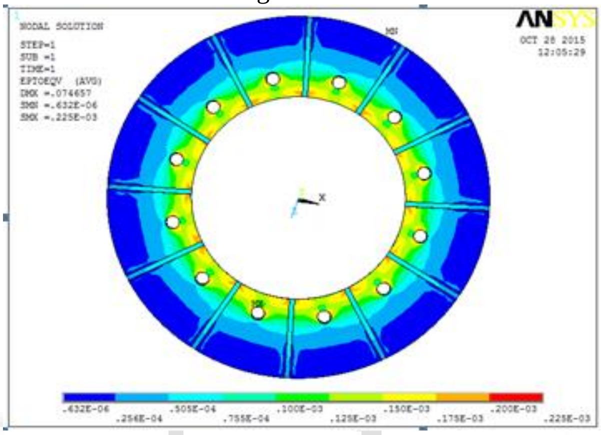

Fig. 7: Strain

V. Composite Analysis

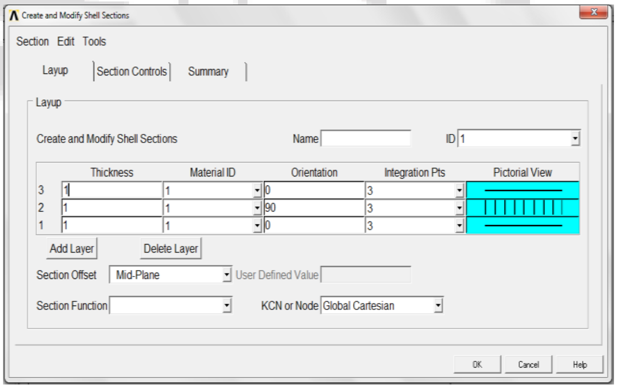

Fig. 8: Three Layer Orientation of Fibre (0-90-0)

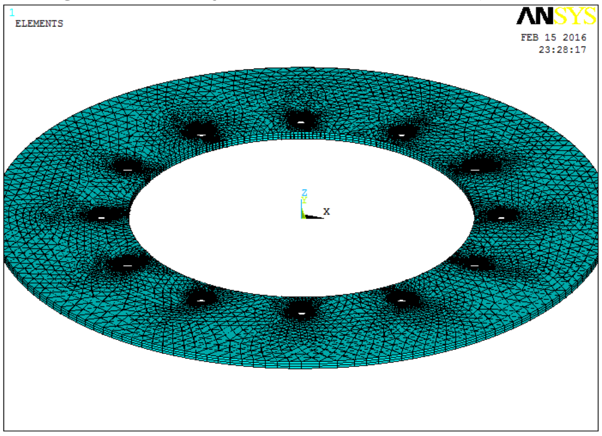

Fig. 8: Three Layered Meshed Composite Model

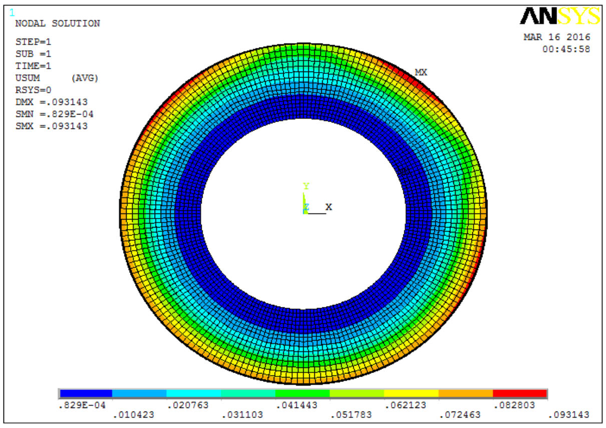

Fig. 9: Displacement

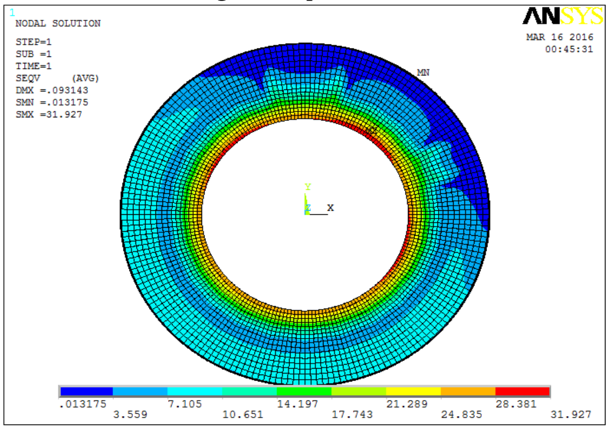

Fig. 10: Stress

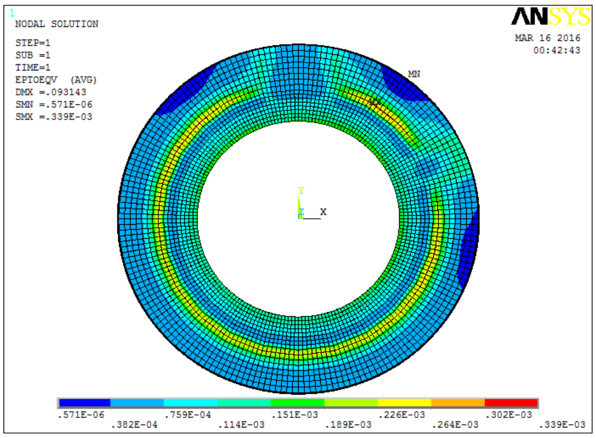

Fig. 11: Strain

S No.	STRESS(Nm^{-2})	STRAIN	DISPLACEMENT (mm)
CAST IRON	26.997	0.000225	.0746
CFRP	157.977	0.001971	0.196519
GFRP	99.63	0.003863	0.599695
BORON EPOXY	107.32	0.002323	0.213564
HT GRAPHITE	31.927	0.000339	0.093143

Table 4: Results

VI. Calculations

A. Area Of Designed Clutch Plate

$=[pi(r_o^2-r_i^2)]-[12*pi*r_h^2]$
$=[3.14(114^2-64^2)]-[12*3.14*3^2]$
$=27620.882\ mm^2$

B. Volume

=Area*thickness of plate
=27620.882*3
$=82862.647\ mm^3$

C. Mass

=volume*density
$=82862.647*7800*10^{-9}$
=0.646328 kg (For Cast Iron)
$=82862.647*1750*10^{-9}$
=0.145009633 kg (For HT Graphite)

D. Weight Reduction

Weight ratio cast iron to HT Graphite clutch plate
=0.646328/0.1450096333
=4.457142834
(MEANS CAST IRON IS 4.45 TIMES HEAVIER THAN HT GRAPHITE)

E. Weight Saving In Percentage

Percentage reduction in weight
= (0.646328-0.145009633)/0.646328*100
=77.6034262%
(MEANS THAT 77 PERCENT WEIGHT IS REDUCED IF HT GRAPHITE USED INSTEAD OF CAST IRON)

F. Strength To Weight Ratio

For Cast Iron (E/ρ) -
$=(120000/7800)*10^9 =1.53*10^{10}$
For HT Graphite (E/ρ) -
$=(221000/1750)*10^9 =12.62*10^{10}$
Ratio of CI and HT graphite E/ρ
= 12.62/1.53 = 8.24
(Hence HT Graphite is 8.24 times stronger than Cast Iron.)

G. Thermal Conductivity

CAST IRON- 55 WmK^{-1}
HT GRAPHITE-85 WmK^{-1}
(Hence it can be concluded that HT graphite has more heat dissipation capacity.)

VII. Conclusion

The weight is reduced by 77 percent and the stress generated is nearly same as cast iron.HT graphite is 4.5 times lighter than cast iron. The thermal conductivity of HT Graphite is nearly 1.6 times that of cast iron.HT graphite is 8.24 times stronger than cast iron. Hence it can be concluded that if HT graphite is used as clutch plate material then the above benefits are obtained.

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