

Static and Dynamic Analysis of Single Plate Clutch

B.Sreevani¹, M.Murali Mohan²

P.G Student, Dept. of Mechanical Engineering, GPREC (JNTUA), Kurnool, A.P, India¹

Assistant Professor, Dept. of Mechanical Engineering, GPREC (JNTUA), Kurnool, A.P, India²

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 material E Glass Epoxy and Aluminium Metal Matrix Composite are taken. A single plate clutch is designed and modeled using Creo 2.0 software. Static analysis and Dynamic analysis is done on the clutch to determine stresses and deformations using materials Grey Cast Iron, Aluminium alloy 7075, E Glass Epoxy and Aluminium Metal Matrix Composite. Analysis is done in Ansys. Theoretical calculations are also done to determine stresses.

KEYWORDS: Pro-E, ANSYS, Analysis, FEM.

1. INTRODUCTION

A clutch is a mechanical device which provides driving force to another mechanism, typically by connecting the driven mechanism to the driving mechanism. Its opposite component is a brake, which inhibits motion.

Clutches are useful in devices that have two rotating shafts. In these devices, one shaft is typically attached to a motor or other power unit (the driving member), and the other shaft (the driven member) provides output power for work to be done. In a drill, for instance, 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). 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. Clutches allow a high inertia load to be started with a small power.

1.1 Single Plate Clutch

A much more power type of clutch is the single-plate clutch as shown in which a single flat circular plate is gripped between the inside face of the flywheel and a clamping plate which is made to grip the clutch plate by means of clamping levers actuated by strong spring. The amount of pressure put on the clamping plate can be varied by adjusting pins on which the end of the clamping levers pivot. The inside face of the flywheel and a clamping plate which is made to grip the clutch plate by means of clamping levers actuated spring.

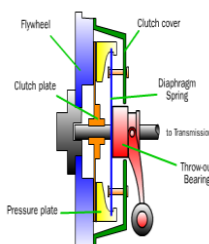


Fig -1: Single plate clutch

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 4, Issue 9, September 2015

1.2 METHOD OF ANALYSIS

The torque that can be transmitted by a clutch is a function of its geometry and the magnitude of the actuating force applied as well the condition of contact prevailing between the members. The applied force can keep the members together with a uniform pressure all over its contact area and the consequent analysis is based on uniform pressure condition.

condition may no longer prevail. Hence the analysis here is based on uniform wear condition.

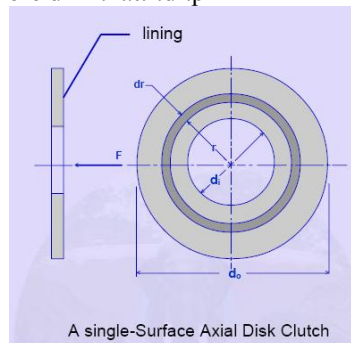
Elementary Analysis

Assuming uniform pressure and considering an elemental area $dA = 2\pi.r.dr$

The normal force on this elemental area is

$$dN = 2.\pi.r.dr.p$$

The frictional force dF on this area is therefore $dF = f.2.\pi.r.dr.p$



Now the torque that can be transmitted by this elemental are is equal to the frictional force times the moment arm about the axis that is the radius 'r'

$$\text{i.e. } T = dF.r = f.dN.r = f.p.A.r$$

$$= f.p.2.\pi.r.dr.r$$

The total torque that could be transmitted is obtained by integrating this equation between the limits of inner radius r_i to the outer radius r_o

$$T = \int_{r_i}^{r_o} 2\pi p f r^2 dr = \frac{2}{3} \pi p f (r_o^3 - r_i^3)$$

Integrating the normal force between the same limits we get the actuating force that need to be applied to transmit this torque.

$$F_a = \int_{r_i}^{r_o} 2\pi p r dr$$

$$F_a = \pi (r_o^2 - r_i^2) . p$$

Equation 1 and 2 can be combined together to give equation for the torque

$$T = f F_a \cdot \frac{2}{3} \frac{(r_o^3 - r_i^3)}{(r_o^2 - r_i^2)}$$

1.3 INTRODUCTION TO PRO/ENGINEER

Pro/ENGINEER Wildfire is the standard in 3D product design, featuring industry-leading productivity tools that promote best practices in design while ensuring compliance with your industry and company standards. Integrated Pro/ENGINEER CAD/CAM/CAE solutions allow you to design faster than ever, while maximizing innovation and quality to ultimately create exceptional products.

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 4, Issue 9, September 2015

1.4 INTRODUCTION TO ANSYS

ANSYS is general-purpose finite element analysis (FEA) software package. Finite Element Analysis is a numerical method of deconstructing a complex system into very small pieces (of user-designated size) called elements. The software implements equations that govern the behaviour of these elements and solves them all; creating a comprehensive explanation of how the system acts as a whole.

Static Analysis-Used to determine displacements, stresses, etc. under static loading conditions. ANSYS can compute both linear and nonlinear static analyses. Nonlinearities can include plasticity, stress stiffening, large deflection, large strain, hyper elasticity, contact surfaces, and creep.

Transient Dynamic Analysis - Used to determine the response of a structure to arbitrarily time-varying loads. All nonlinearities mentioned under Static Analysis above are allowed.

II. LITERATURE REVIEW

The paper published by Mamta G. Pawar^[1] Clutch system is among the main systems inside a vehicle. Clutch is a mechanical device located between a vehicle engine and its transmission and provides mechanical coupling between the engine and transmission input shaft. Clutch system comprise of flywheel, clutch disc plate and friction material, pressure plate, clutch cover, diaphragm spring and the linkage necessary to operate the clutch. The clutch engages the transmission gradually by allowing a certain amount of slippage between the flywheel and the transmission input shaft.

Shrikant V. Bhojar^[2], a simple transmission system consisting of engine, clutch, gearbox and load is designed for the load lifting application. Stiffness of all the three shafts have been calculated and equivalent stiffness is calculated. Equivalent mass moment of inertia is also calculated. From this data, using the concepts given by Prof. DOW, duration of engagement period is calculated for the selected power transmission system and energy dissipated during engagement is also plotted as a function of time. Anil Jadhav^[3], depicts a solid modelling of multiplate clutch with PRO-E CAD package that is employed for varied automotive applications. The structural analysis of clutch plate is done over cork, copper and SA92 as friction lining materials. The analysis is carried out on ANSYS workbench to get the foremost appropriate friction material for clutch. From the analyzed results, stress, strain and total deformation values were compared for all the three materials and the best one was taken out. Prafull. S. Thakare^[4], Clutch is a device used in the transmission system of a vehicle to engage and disengage the transmission system from the engine. The clutch works on the principle of friction. This paper discusses detailed study of single plate clutch. In this paper, detail study of clutch and modeling of clutch is done in proe software. Assembly of different parts of the single plate clutch is also done in software. Nitinchandra R. Patel^[5], the centrifugal clutch offers many advantages in motor and engine drive applications. Utilizing the centrifugal clutch enables the selection of normal torque motors for running loads rather than the selection of high torque motors for starting loads. The aim of this project is to be describing the torque carrying capacity at different speed which using in transmitting power. V Mani Kiran Tipirineni^[6], the driven plate used in Leyland Viking Vehicle is analyzed in this work. The driven main plate failed normally during its operation due to cyclic loading. This project explains the structural design analysis of the clutch plate and find out the failure region by doing static analysis in ANSYS software. The 3D model of clutch plate was drafted using Solid works software and analysis of the plate was done for static loading condition. This project finds the maximum stress in failure region during operation.

III. PROBLEM DESCRIPTION

Previous work has been done on the sintered iron friction material clutch plate and dynamic analysis of cracks in composite materials. Static and dynamic analysis of clutch plate had also been done to observe the clutch before crack and after crack but the crack propagation and growth were not observed.

METHODOLOGY The present work is investigate how a crack propagates grows in a clutch. The finite element program ANSYS is used to simulate crack growth and to compute the stresses and the stress-intensity factor. A Geometric model of clutch was designed in 3D by using software Creo. The materials of the clutch considered are ceramic material which can withstand high pressure, temperature, and strength of the material.

IV. DESIGN CALCULATIONS

1) CAST IRON

Pressure (p)= (P_{max} x r_i)/r_o

$$F_n = \int_{r_i}^{r_o} p dA \quad [P_{max}=0.69]$$

$$= \int_{r_i}^{r_o} ((P_{max} \times r_i)/r_o) \times 2\pi r dr$$

$$= 2\pi P_{max} \times r_i \int_{r_i}^{r_o} dr$$

P_{max}= maximum permissible stress

R_i=inner radius of single plate clutch

R_o=outer radius of single plate clutch

$$= [2\pi (0.69 \times 10^3) \times r_i (r_o-r_i)]/r_o$$

$$=[2\pi (0.69 \times 10^3) \times 64 (114-64)]/114$$

F_n=121695.3786 N

Area = 25217.6 mm²

Stress=F/A

=121695.3786/25217.6

=4.8 N/mm²

2) ALUMINIUM 7075

Pressure (p)= (P_{max} x r_i)/r_o

$$F_n = \int_{r_i}^{r_o} p dA \quad [P_{max}=0.28]$$

$$= \int_{r_i}^{r_o} ((P_{max} \times r_i)/r_o) \times 2\pi r dr$$

$$= 2\pi P_{max} \times r_i \int_{r_i}^{r_o} dr$$

$$= [2\pi (0.28 \times 10^3) \times r_i (r_o-r_i)]/r_o$$

$$=[2\pi (0.28 \times 10^3) \times 64 (114-64)]/114$$

F_n=49383.63 N

Area = 25217.6 mm²

Stress=F/A

=49383.63 /25217.6

=1.9 N/mm²

3) ALUMINIUM MMC

Pressure (p)= (P_{max} x r_i)/r_o

$$F_n = \int_{r_i}^{r_o} p dA \quad [P_{max}=0.43]$$

$$= \int_{r_i}^{r_o} ((P_{max} \times r_i)/r_o) \times 2\pi r dr$$

$$= 2\pi P_{max} \times r_i \int_{r_i}^{r_o} dr$$

$$= [2\pi (0.43 \times 10^3) \times r_i (r_o-r_i)]/r_o$$

$$=[2\pi (0.43 \times 10^3) \times 64 (114-64)]/114$$

F_n=75839.14897 N

Area = 25217.6 mm²

Stress=F/A

=75839.14897 /25217.6

=3.0 N/mm²

4) E GLASS EPOXY

Pressure (p)= (P_{max} x r_i)/r_o

$$F_n = \int_{r_i}^{r_o} p dA \quad [P_{max}=0.586]$$

$$= \int_{r_i}^{r_o} ((P_{max} \times r_i)/r_o) \times 2\pi r dr$$

$$= 2\pi P_{max} \times r_i \int_{r_i}^{r_o} dr$$

$$= [2\pi (0.586 \times 10^3) \times r_i (r_o-r_i)]/r_o$$

$$=[2\pi (0.586 \times 10^3) \times 64 (114-64)]/114$$

F_n=103333.389 N

$$\begin{aligned} \text{Area} &= 25217.6 \text{ mm}^2 \\ \text{Stress} &= F/A \\ &= 103333.389 / 25217.6 \\ &= 4.097 \text{ N/mm}^2 \end{aligned}$$

V. ANALYSIS OF SINGLE PLATE CLUTCH

STRUCTURAL ANALYSIS

5.1.1 Aluminum alloy 7075

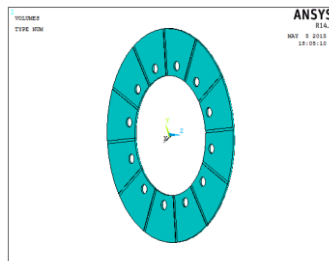


Figure 5.1: Imported from PRO-E

Element type - Solid20 Node 95

Material Properties

Young's modulus..... 71700Mpa

Poisson ratio.....0.33

Density – 0.0000281 kg/m³



Figure 5.2 Meshed Model

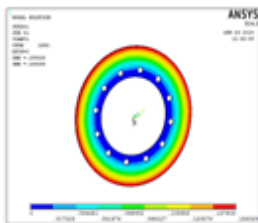


Figure 5.3 Displacement

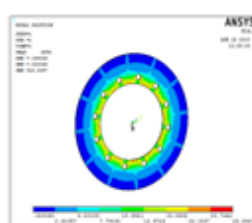


Figure 5.4 stress

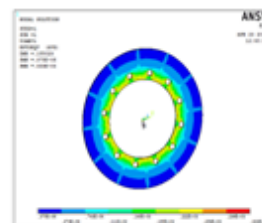


Figure 5.5 Strain

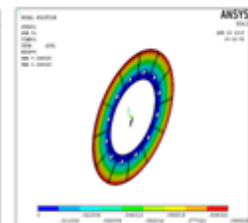


Figure 5.6 Displacement

5.1.2 ALUMINIUM MMC

Material Properties

Young's modulus..... 115000Mpa

Poisson ratio.....0.30

Density – 0.0000288 kg/m³

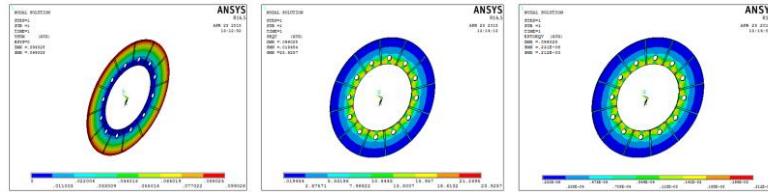


Figure 5.6 Displacement Figure5.7 stress Figure5.8 Strain

5.1.3 GRAY CASTIRON

Material Properties

Young's modulus..... 120000Mpa

Poisson ratio.....0.29

Density – 0.0000072kg/m³

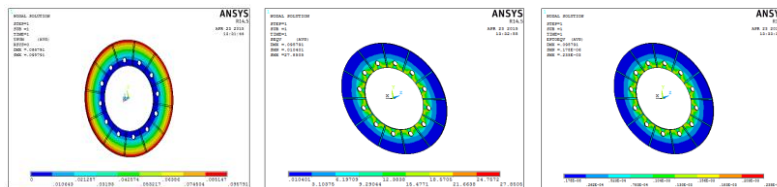


Figure 5.9 Displacement Figure 5.10 Stress Figure 5.11 Strain

5.1.4 E-GLASS EPOXY

Material Properties

Young's modulus..... 27600Mpa

Poisson ratio.....0.34

Density-0.0000019kg

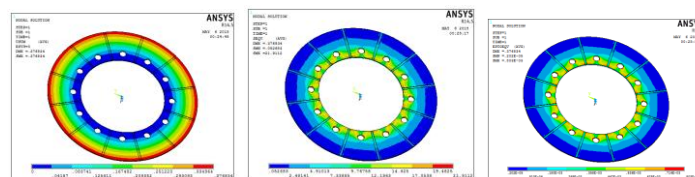


Figure 5.12 Displacement Figure 5.13 Stress Figure 5.14 Strain

VI. DYANAMIC ANALYSIS

6.1.1 ALUMINIUM7075

Material Properties

Young's modulus..... 71700Mpa

Poisson ratio.....0.33

Density – 0.00000281Kg/m³

AT 10SEC

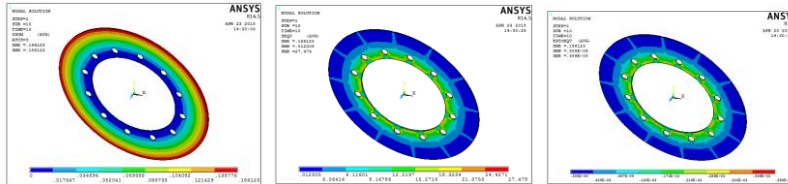


Figure 6.1 Displacement

Figure 6.2 Stress

Figure 6.3 Strain

AT 20SEC

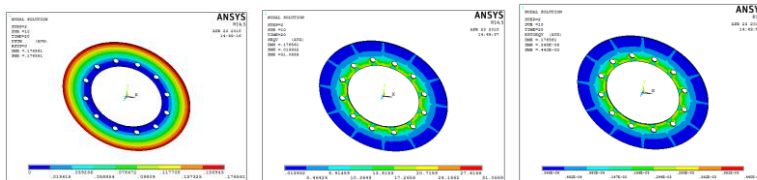


Figure 6.4 Displacement

Figure 6.5 Stress

Figure 6.6 Strain

AT 30SEC

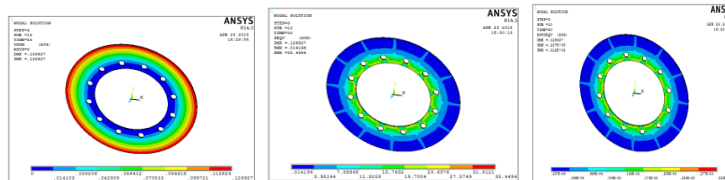


Figure 6.7 Displacement

Figure 6.8 Stress

Figure 6.9 Strain

AT 10SEC

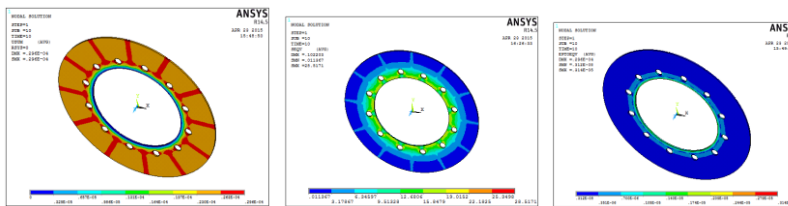


Figure 6.10 Displacement

Figure 6.11 Stress

Figure 6.12 Strain

AT 20SEC

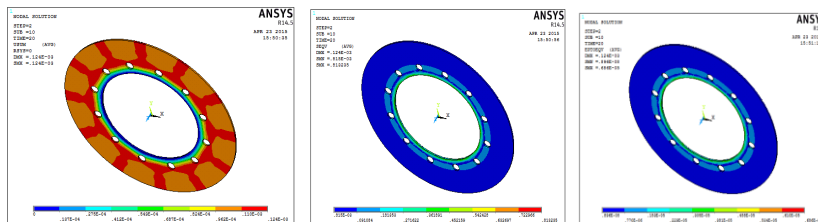


Figure 6.13 Displacement

Figure 6.14 Stress

Figure 6.15 Strain

AT 30SEC

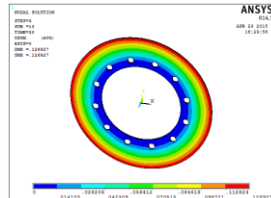


Figure 6.16 Displacement

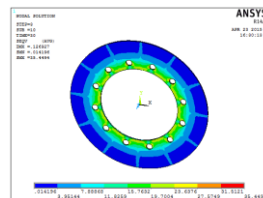


Figure 6.17 Stress

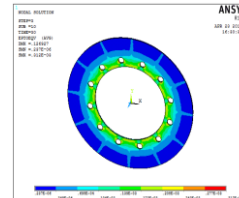


Figure 6.18 Strain

**6.1.3 CAST IRON
Material Properties**

Young's modulus..... 120000Mpa

Poisson ratio.....0.29 Density – 0.0000072 kg/m³

6.1.4 E-GLASS EPOXY

AT 10SEC

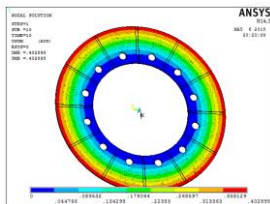


Figure 6.19 Displacement

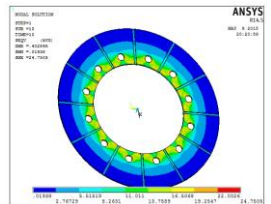


Figure 6.20 Stress

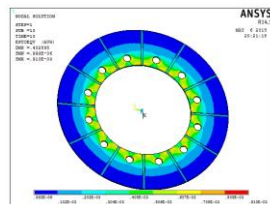


Figure 6.21 Strain

AT 20SEC

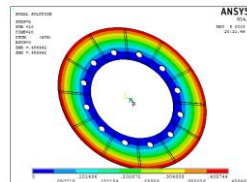


Figure 6.22 Displacement

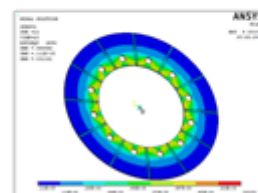
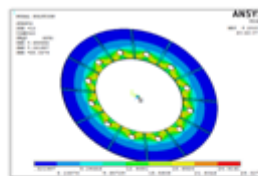


Figure 6.33 Strain

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 4, Issue 9, September 2015

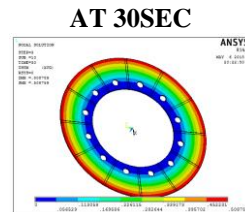


Figure 6.34 Displacement

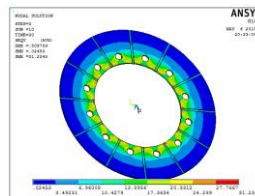


Figure 6.35 Stress

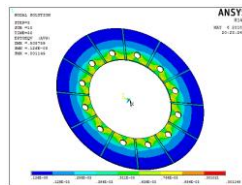


Figure 6.36 Strain

VI. RESULTS

STRUCTURAL ANALYSIS TABLE

ALUMINIUM 7075	0.155029	23.3347	0.333e-03
ALUMINIUM MMC	0.099028	23.9257	0.212e-03
GRAY CAST IRON	0.095791	27.8505	0.235e-03
E-GLASS EPOXY	0.376834	21.9112	0.803E-03

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 4, Issue 9, September 2015

DYNAMIC ANALYSIS TABLE

AT 10SEC

	Displacement(mm)	Stress (MPa)	Strain
Aluminum7075	0.156123	27.479	0.389E-03
Aluminum MMC	0.102203	28.5171	0.251E-03
Grey cast Iron	0.296E-04	37.1644	0.314E-05
E-Glass Epoxy	0.402895	24.7505	0.910e-03

AT20SEC

	DISPLACEMENT(mm)	STRESS (MPa)	STRAIN
ALUMINUM 7075	0.176561	31.0669	0.440E-03
ALUMINIUM MMC	0.115792	32.2951	0.284E-03
GRAY CAST IRON	0.124E-03	0.813235	0.686E-05
E-GLASS EPOXY	0.456462	28.0279	0.001031

AT30SEC

	DISPLACEMENT(mm)	STRESS (MPa)	STRAIN
ALUMINIUM 7075	0.196805	34.6237	0.490E-03
ALUMINIUM MMC	0.126927	35.4494	0.312E-03
GRAY CAST IRON	0.293E-03	1.32872	0.112E-04
E-GLASS EPOXY	0.508759	31.2345	0.001149

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 4, Issue 9, September 2015

VII. CONCLUSION

In this thesis, a single plate clutch is modelled in 3D modelling software Creo 2.0. Present used material for clutch is Cast Iron. In this thesis, it is replaced with Aluminium alloy 7075, Aluminium metal matrix composite and composite material E – Glass Epoxy. The advantage of using aluminium alloys is their light weight. The advantage of using composite material is their strength to weight ratio. By observing the static analysis results, the analysed stress values are less than the respective yield stress values of Aluminium alloy 7075, aluminium MMC and E – Glass epoxy. So using the materials is safe. By comparing the results between materials, E – Glass Epoxy is more advantageous than other materials due to its less weight and high strength.

Theoretical calculations are also done to determine stresses for all the materials. By observing the results, the stress values are less than the respective allowable stress values for all materials. By observing the E Glass Epoxy results, the stress value is less.

So it can be concluded that by analytical and theoretical results, E Glass Epoxy is better.

REFERENCES

- [1]. Design and Analysis of Clutch Using Sintered Iron as a Friction Material by Mamta G. Pawar, Monarch K. Warambhe, Gautam R. Jodh, International Journal of Innovative Technology and Exploring Engineering (IJITEE), ISSN: 2278-3075, Volume-3, Issue-7, December 2013
- [2]. Dynamic Analysis Of Single Plate Friction Clutch by Shrikant V. Bhojar, Dr. G. D. Mehta, Dr. J. P. Modak, International Journal of Engineering Research and Technology, ISSN: 2278-0181
- [3]. Static Structural Analysis of Multiplate Clutch with Different Friction Materials by Anil Jadhav, Gauri Salvi, Santosh Ukamnal, Prof. P. Baskar, , International Journal of Engineering Research and Technology, ISSN: 2278-0181
- [4]. Thermo-mechanical Analysis of the Dry Clutches under Different Boundary Conditions by O.I. Abdullaha, Schlattmanna, A.M. Al-Shabibi, Vol.36, No.2(2014)172-180, Tribology in Industry
- [5]. Modelling and assembly of single plate friction clutch of an automobile by Prafull. S. Thakare , Vishal J. Deshbhratar AND Abhinav. P. Ninawe, Indian Streams Research Journal, Volume : II, Issue : II, March – 2012
- [6]. Dynamic analysis of single plate friction clutch by Shrikant V. Bhojar, G.D. Mehta, J.P. Modak
- [7]. Optimal Design of a Clutch Plate using Ansys by V Mani Kiran Tipirineni, P. Punna Rao
- [8]. Structural Analysis of Multiplate Clutch using ANSYS by Bony Chrisol Joseph, M Vasundara
- [9]. Clutch plate using woven hybrid composite materials by A Alavudeen; M Thiruchitrabalam; A Athijayamani