RESEARCH ARTICLE OPEN ACCESS

Static Structural Analysis of Multiplate Clutch Friction Lining with Various Friction Materials

Mayank Chouhan[1], Dheeraj Mandliya[2], Vikas Sharma[3]
[1]M. Tech Research Scholar, [2]Guide and Assistant Professor, [3]Head of Department
Department of Mechanical Engineering, Malwa Institute of technology, Indore

ABSTRACT
Clutch is a mechanical instrument. It's a system that engages to continuous the effluent of power from engine to gearbox and disengages to cut the power from engine to gearbox. It is mounted in the central of the gear assembly and engine. A multiplate clutch is important roles in the gear box. Good design of clutch gives superior engine performance. Multiplate clutch is extremely used in motorcars, motorbikes, and heavy-duty vehicles. Whenever high torque transmission be expected and restricted place is available. The Clutch disc is made of Structural Steel. The material used for the lining of friction surface is Cork, Asbestos, Ceramic, Kevlar, Sintered Iron, Cast iron, and Powder metal. The multiplate clutch has designed in Creo parametric and imported in Ansys workbench 19.2 for automotive application. The structural analysis is implemented for the friction material clutch plate lining. The result of friction material is depend on static structural analysis, stress, total deformation and strain of the friction plate. Structural analysis is performed for a clutch plate using properties of the material. Material used for Cork, Nao (Non-Asbestos Organic), and Alumina. A comparison result is performed for the materials to recognized better friction lining materials for the clutch plate.
***Keywords* —** Ansys, Alumina,Creo, Cork, Nao (Non-Asbestos Organic), Stress, Strain, Total deformation.

Date of Submission: 01-09-2020 Date of Acceptance: 16-09-2020

I. INTRODUCTION

1.1 Clutch

The clutch is a mechanical instrument. The transmission system is used in the vehicle to engage and destroy the transmission system from the engine. The friction clutch is a necessary part of any automotive machine. The clutch is placed in the central of the engine and the transmission system. Which conducts power, as torque from engine to gear assembly. When the clutch is in place, the engine will be associated to the transmission, and power will flow from the engine to the nearest wheels via a transmission system. Then, as soon as the clutch is disengaged, on hold down the clutch pedal will cause the engine to disengage from the transmission. In this way, the power doesn't access to rear wheel. Whereas the engine is even now running.

1.2 Types of friction clutch.

Generally, there are two categories of friction clutch

- Single plate clutch
- Multiplate clutch.

Single plate clutch is utilized in small duty vehicle.Single plate clutch is a form of friction clutch in which power is usually transmitted through friction among the contact surfaces which is usually termed clutch plates.

1.3 Multiplate clutch

Multiplate clutch is utilized in cars, bikes and heavy-duty vehicles. It consists of more than one set of pressure plate and friction plates. As the quantity of plates increased, the friction surface as well increased. The increase quantity of friction surfaces increased the competence of the clutch to transmit torque. The friction between two surfaces depend upon pressure applied on them, area of friction. Whenever high torque transmission be expected and restricted place is available. The Clutch disc is made of Structural Steel. The material used for the lining of friction surface is Asbestos, Ceramic, Kevlar, Cork, Sintered Iron, Cast iron, and Powder metal. Works on the clutch theory of friction because were the two-rough surface. Clutch plates come into link with each other and are pressed so that the friction between them causes the composite. One is circled the other will also circled. Then they become to around as a single unit. The friction among two surfaces relies on the surface area, the pressure applied them, and the coefficient of friction of thesurfacematerials.

Figure. 1 clutch plate

1.4 Required of good clutch facing.
- Relatively highly coefficient of friction.
- It should have high heat resistance
- It should be easy to manufacture.
- Must have sufficient shear strength to transmit torque.
- Friction property must be maintained over the entire working life.

1.5 Many kinds of clutch failures
- Burnt Pulley, hub and Coil.
- Bearing failure.
- Noisy Bearing.
- Un-burnished clutch.
- Inappropriate propeller to pivot air hole.
- Using the wrong belt or the wrong clutch

Open circuit within field loop.
- Flange welds mounting the failed field coil.
- Faulty lead wire.

II. OBJECTIVES

The objectives of this task are to demonstrate the structural analysis of the clutch plate with different friction linings and to choose the most convenient one.
- Solid modeling of multiplate clutch assembly.

➢ **Objectives of Multiplate clutch**
- Resolution of intensity of axial pressure according to rated torque.
- Resolution of von mises stress.
- Resolution of von mises strain.
- Resolution of total deformation.
- Comparison of the design parameters.

III. METHODOLOGY

The dimensions of multiplate clutch are gathered from the CB Unicorn model. The model of clutch designed in Creo software.

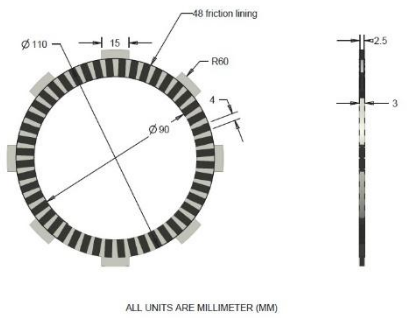

Figure 2. Model of clutch plate

3.1 Material Selection

A multiplate Clutch is made of Structural Steel and the material being used for the lining of friction surface on the clutch plate is Cork, Nao and Alumina.

3.2 Engineering data

Table 1. Properties of materials

Mechanical Properties	**CORK**	**NAO**	**ALUMINA**
Young's modulus (Mpa)	32	2300	384000
Poisson's ratio	0.25	0.25	0.27
Yield stress (MPa)	1.4	12.65	240
Co-efficient of friction	0.3	0.3	0.3
Density (kg/m3)	205	2310	2950

3.3 Design consideration

For a multiplate clutch, the quantity of discs on driving and driven shaft is determined by the amount of sets of contact surfaces.

In this theory, the multiplate clutch is deputed has eight sets of surfaces in contact (i.e. n=8).

n = number of sets of contact surfaces

$n = n_1 + n_2 - 1$

$n_1 = 5$ (no. of disc on driving shaft)

$n_2 = 4$ (of disc on driven shaft)

Hence n = 8;

Rated torque = 12.80 N-m = 12.80×10^3 N-mm @5500 RPM

Power = 12.91 BHP @ 8000RPM;

r_1 and r_2 are external and the internal radius of friction faces,

Where

r_1 =110 mm and r_2 = 90 mm;

R = mean radius of friction surfaces

3.3.1 Assuming uniform pressure theory:

For uniform pressure:

$R = 2(r_1^3 - r_2^3) / 3(r_1^2 - r_2^2)$

$R = 2(110^3 - 90^3) / 3(110^2 - 90^2)$

R = 100.33 mm

The intensity of pressure when pressure is evenly distributed over the entire area of the friction face 'P',

$P = W / \pi (r_1^2 - r_2^2)$

W = Axial thrust with which friction surfaces are put together.

A frictional torque executive on the friction surfaces or on the clutch is given by,

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

μ = co-efficient of friction

We know that,

$T = 12.80 \text{ X } 10^3$ N-mm

From the above equation,

$12.80 \text{ X } 10^3 = 8 \times 0.3 \times W \times 100.33$

Therefore,

W = 53.15 N

$P = W / \pi (r_1^2 - r_2^2) = 53.15 / \pi (110^2 - 90^2)$

$P = 4.229 \text{X} 10^{-03}$ N/mm^2

3.3.2 Assuming uniform wear theory:

For uniform wear:

$R = r_1 + r_2/2 = 110+90/2$

R = 100 mm

We know that, according to uniform wear theory, the intensity of the pressure is inversely proportional to the radius of friction plate

$P \times r = C$ ($C = constant$)

Axial force essential to enclosed the clutch,

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

Torque transmitted,

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

$12.80 \times 10^3 = 8 \times 0.3 \times W \times 100$

Therefore, W= 53.33 N

The total force acting on a friction surface is given by,

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

$C = 53.33 / 2\pi (110-90)$

C = 0.4243 N-mm

We know that, the intensity of pressure is utmost at the internal radius (r_2) of friction or contact surface.

Thus, the equation is written as,

$P_{max} \times r_2 = C$

That is,

$P_{max} = 0.4243/90$

$P_{max} = 4.7144 \text{ X } 10^{-03}$ MPa

$P_{max} = 0.004714$ Mpa

The Intensity of pressure is least at the external radius (r_1) of friction or contact surface.

Thus, the equation is written as,

$P_{min} \times r_1 = C$

That is, Pmin = 0.4243/110

$P_{min} = 3.8572 \text{ x } 10^{-03}$ MPa

$P_{min} = 0.003857$ MPa

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

P_{avg} =Total force on friction surface/ cross-sectional area of frictional surface

$P_{avg} = W / \pi (r_1^2 - r_2^2)$

$P_{avg} = 53.33 / \pi (110^2 - 90^2)$

$P_{avg} = 4.243 \text{ x } 10^{-03}$

$P_{avg} = 0.004243$ N/mm^2

In this theory, utmost pressure considered from uniform wear theory, is applicable for analyzing design criteria of the clutch plate.

IV. RESULT

The design criterion (Von Mises stress, total deformation and Von Mises strain) derived from the analysis were utilized to theory the character of friction materials (Cork, Nao and Alumina) on the clutch plate.

4.1. Clutch plate analysis using Cork as a friction material.

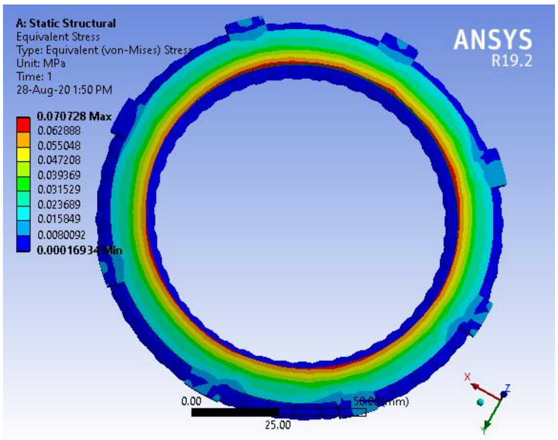

Figure 3. Von-Mises Stresses

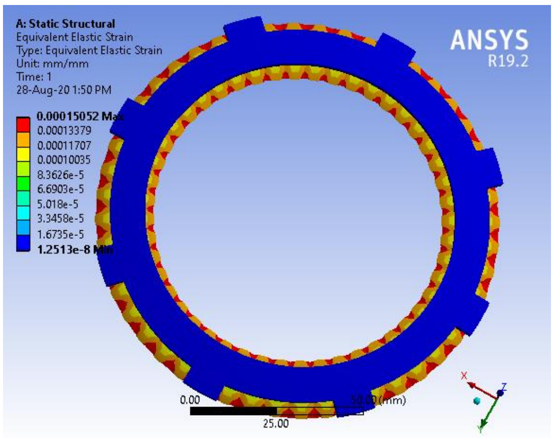

Figure 4. Von-Mises Strain

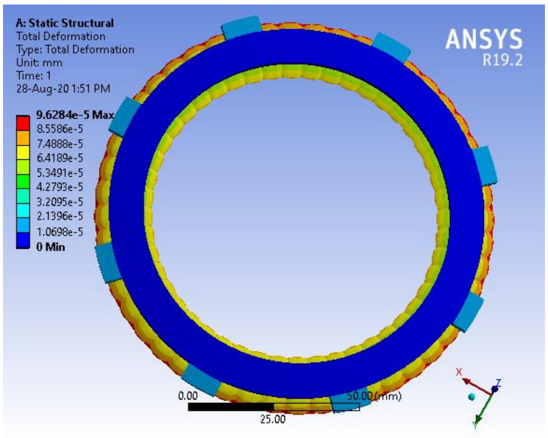

Figure 5. Total deformation

4.2. Clutch plate analysis using Nao (Non-Asbestos Organic) as a friction material.

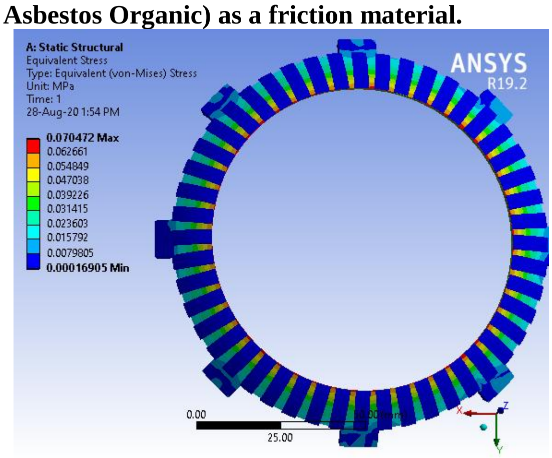

Figure 6. Von-Mises Stresses

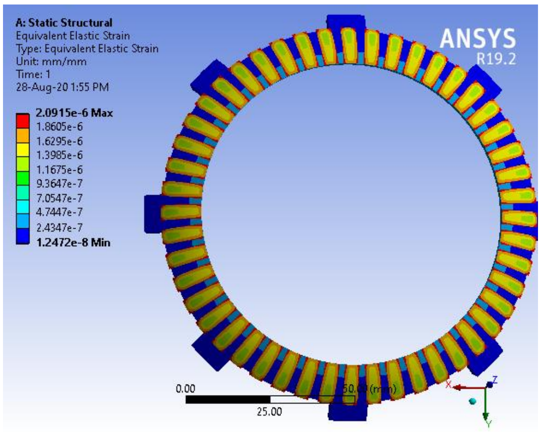

Figure 7. Von-Mises Strain

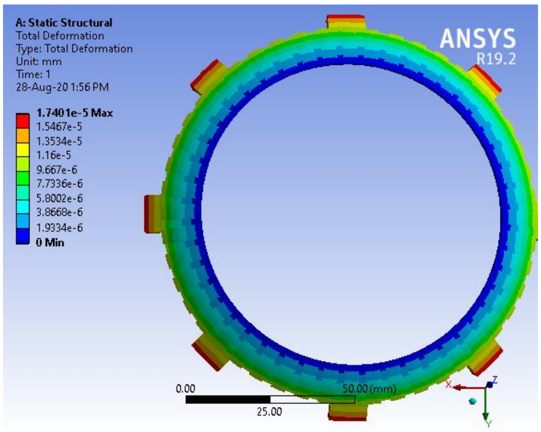

Figure 8. Total deformation

4.3. Clutch plate analysis using Alumina as a friction material.

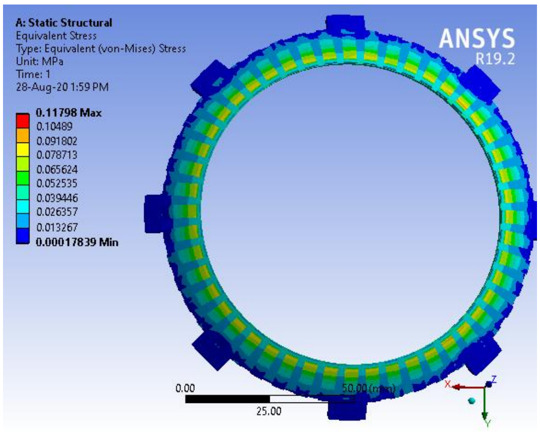

Figure 9. Von-Mises Stresses

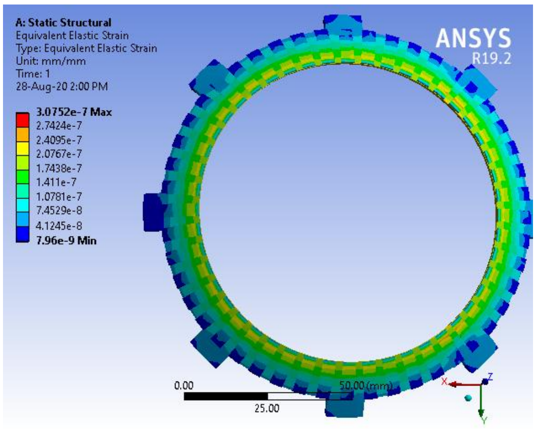

Figure 10. Von-Mises Strain

ISSN: 2248-9622, Vol. 10, Issue 9, (Series-IV) September 2020, pp. 29-34

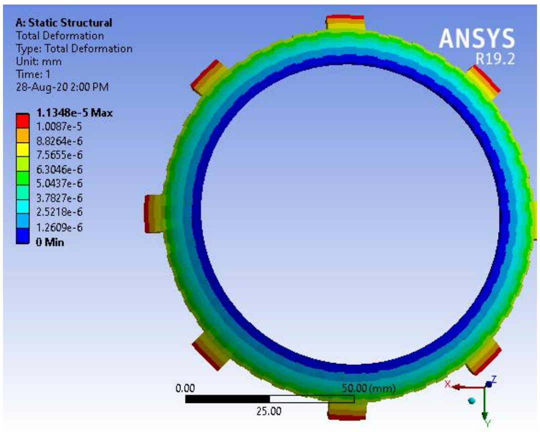

Figure 11. Total deformation

Table 2. Analyzed results
After the static structural analysis done by ANSYS on friction plate lining of a multi plate clutch based on given boundary conditions the obtained results are tabulated below.

Friction Material	Von Mises Stress (Mpa)	Von Mises Strain	Total Deformation (mm)
Cork	0.070728	0.00015052	$9.6284e^{-5}$
Nao	0.070472	$2.0915e^{-6}$	$1.7401e^{-5}$
Alumina	0.117980	$3.0752e^{-7}$	$1.1348e^{-5}$

Show the variation in strength of three materials. From the analyzed result is observed that the maximum stress developed in Nao is lesser than that of Cork and Alumina. And which implies that Nao has low wear rate and stable friction performance. The total deformation and strain developed in Nao is lesser than that of Cork and greater than that of Alumina.

V. CONCLUSIONS

In this project, a part model of multiplate clutch is designed in creo parametric software. Structural analysis on the clutch plate has been analyzed in ANSYS workbench 19.2 for Cork, Nao and Alumina as friction lining materials. Finally, since this analysis it may be decided that, on the basis strength, NAO is more convenient and quite preferable friction material than cork for the same rated torque.

FUTURE SCOPE
2D and 3D Computations were done for multiplate clutch in present analysis. Some of the suggested work is outlined below

- Thermal analysis can be generated for multi-plate clutch with various temperatures.
- We may reduce the thickness of friction lining material of multiplate clutch.
- We can change the profile of friction lining such as fillet, chamfer and taper.
- Static structural analysis can be performed with various composite friction materials.
- For the present case only, computations were performed. Fabrication work can be done.

REFERENCES

[1]. Mukesh Kumar and Jayashree Bijwe, "Non-asbestos organic (NAO) friction composites: Role of copper; its shape and amount", ScienceDirect ELSEVIER, Available 10 November 2010
[2]. G. Shanthi and S. Praveen Kumar, "Finite Element Analysis on Friction Plate of a Wet Multiple Clutch by Using Various Friction Materials", International Research Journal of Engineering and Technology (IRJET), Volume: 04 Issue: 08 | Aug -2017
[3]. K. S. Aravindh, P Uma Mahesh, K Mohan Krishna and J Sai Sandeep, "Fem Analysis of Wet Multi Plate Clutch by Varying Friction Surface Material", International Research Journal of Engineering and Technology (IRJET) Volume: 02 Issue: 06 | Sep-2015
[4]. Rajesh Purohit, Pooja Khitoliya and Dinesh Kumar Koli, "Design and Finite Element Analysis of an Automotive Clutch Assembly", ScienceDirect ELSEVIER, Available 2014
[5]. Animesh Agrawal, Ajay Kumar Verma, Siddharth Jaiswal, "Optimization of Multi Plate Friction clutch for Maximum Torque Transmitting Capacity Using Uniform Wear Theory", ScienceDirect ELSEVIER, Available 2014
[6]. Oday I. Abdullah, Josef Schlattmann, Adolfo Senatore, Abdullah M. Al-Shabibi, "Investigation of thermoelastic problem of multiple-disc friction clutches applying different thermal loads", SPRINGER, Accepted: 4 May 2018
[7]. Gowtham Modepalli, "Clutch Assembly Modeling and Dynamic Analysis", International Journal of Mechanical and Production Engineering, Volume- 3, Issue-11, Nov.-2015
[8]. Anil Jadhav, Gauri Salvi, Santosh Ukamnal, Prof. P. Baskar, "Static Structural Analysis of Multiplate Clutch with Different Friction Materials", International Journal of Engineering Research & Technology (IJERT) Vol. 2 Issue 11, November – 2013

[9]. K. Sai Rohith, G. Suresh and DR.G.P. Ramesh, "Design and Analysis of Automotive Wet Multi Plate Clutch", International Journal of Engineering Research-Online, Vol.8., Issue.1, 2020 Jan-Feb
[10]. SyambabuNutalapati, DR. D. Azad, DR. G. Swami Naidu, "Structural Analysis of Friction Clutch Plate by Changing Fillet Radius", International Journal of Engineering Research-Online, Vol.5., Issue.1., 2017 January-February
[11]. Guguloth Ravi, Thurai Sharat and MalothHeeralal, "Design Evaluation of a Multi Plate Clutch", International Journal of Innovative Research in Technology (IJIRT) | Volume 3 Issue 10 | March 2017
[12]. Pulavarthi Krishram Raju, P. Siva Subramanyam and K. N. D. Malleswara Rao, "Optimal Design and Analysis of Multi Friction Plates Using Creo And Fea Package", Journal of Technological Advances & Scientific Research (JTASR), Vol. 1/ Issue 04/ Oct-Dec. 2015
[13]. Liang Yua and Biao Ma, "Investigation on the failure mechanism and safety mechanical thermal boundary of a multi-disc clutch", ScienceDirect ELSEVIER, Available 2019
[14]. DING Yuan, "Optimal Design for Automobile Friction Clutch", Proceedings of the 2009 IEEE
[15]. Gogarla Sonia and Mr. Saroj Kumar Padhi, "Design and Analysis of Multi-Plate Clutch Unit", International Journal of Research, Volume 03 Issue 14 October 2016
[16]. Sagar Olekar, Kiran Chaudhary, Anil Jadhav and P. Baskar4, "Structural analysis of multiplate clutch", IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE), Volume 10, Issue 1 (Nov. - Dec. 2013).
[17]. KunchalaBrahmaiah And O Hemalatha, "Design and Analysis of Friction Clutch Plate Using Different Materials", International Journal of Management, Technology and Engineering, Volume 8, Issue X, October/2018
[18]. Mr. Vishal J. Deshbhratar and Mr. Nagnath U. Kakde, "Design and Structural Analysis of Single Plate Friction Clutch", International Journal of Engineering Research & Technology (IJERT) Vol. 2 Issue 10, October - 2013
[19]. Pandya and Shah; 2005; Machine Design; Charotar.
[20]. Amar Clutch Mover Indore, GP Rubber and Engineering Works Faridabad.
[21]. Design Data Book by K. Mahadevan, K. Balaveera Reddy.