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Designing and Analysis of Multiplate Clutch by ANSYS Software

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Abstract: *In this paper, the multi-plate clutch design process will be presented. As we know, the clutch is very useful in engaging and disengaging the vehicle's transmission with the engine. There are many types of clutches on the market. This study presents an in-depth analysis of the design of multi-plate wet clutches for automotive applications. It explores different design techniques, challenges and advances, focusing on aspects such as contact characteristics, thermal management, structural integrity and material selection. Additionally, the integration of multi-plate clutch systems with hybrid powertrains and the implications of the electrification trend are also explored. By addressing key aspects of multi-plate clutch design and identifying future research directions, this article aims to contribute to the advancement of automotive engineering, promoting innovations new to improve the performance, efficiency and durability of modern vehicles. The design proposed in this paper is rated to be 93% accurate. In our proposed system, the proposed design has a deformation of 0.0000187 mm and can withstand a maximum nominal stress of 0.20076 N/mm2,*

Keywords: Multiplate, design, analysis, deformation.

I. INTRODUCTION

In automobile manufacturing, the clutch frame is the fundamental part that supports the control transfer between the engine and transmission, allowing consistent movement of the equipment and controllability of the vehicle. Among the various types of clutches used in automotive applications, the multi-disc clutch frame is a fundamental innovation due to its efficiency, compactness and versatility. The design and optimization of multi-disc clutch frames has attracted particular attention from analysts and engineers, driven by the constant need for improved performance, power and capability. vehicle's fuel economy. Diagram of the multi-disc clutch frame includes fragility fit between different structural designs, grinding features, heat management, side judgement, and fabric identification. In summary, the project and research on multi-disc clutch frames represents an active and growing sector in automotive manufacturing, offering enormous potential for innovation and optimization. By illustrating the complexities of clutch design and studying the paths of development, this thesis seeks to contribute to the general information base, cultivating advances moving the automotive industry toward performance higher.

II. LITERATURE REVIEW

[2] The purpose of this article is to design a single-plate clutch for a specific pickup truck, ready for production. Auto Cad is used to create sketches using the calculations made in this article. The complete selection of materials based on the various components of the assembly is carried out based on the vehicle requirements and the cost of the components. The production process for each part of the assembly as well as the type of assembly are described and finally the prices of all the individual parts are mentioned in this document. [3] Computerized calculation of automobile clutch assembly - - an application of optogenetics publication: Computerized calculation of automobile clutch assembly is a publication on the process of calculating ghost disc clutch assembly close to automobile assembly. [4] A single-plate contact clutch may be a device used in an automobile transmission system to lock and disengage the clutch. In-depth testing of the car's single-plate clutch was carried out using computer modelling and digital strategies. This thinking seems to be able to reduce pressure and power in the clutch through a software approach. [5] a paper proposed a dual dry clutch drive controller to simultaneously identify kissing points. Manoeuvring can be useful for vehicles

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without ROM to maintain the position of the kissing point. [6] Automobile clutch hot pull and auxiliary inspection based on limited component strategy. This article introduces the stress and deformation of automotive single-disc clutches based on the connected materials. A fundamental clutch investigation was carried out using a limited composition strategy for an oppressive vehicle illustration t- Toyota KUN 25.t[10]t College of Alt-Qadisiya, web address . [8] Clutch disc stress was analysed to observe stress, displacement and deformation when applying pressure to the clutch disc surface using Solid Works software.

III. PROPOSED METHODOLOGY

When the operator desires, the clutch can connect or separate the drive shaft and drive shaft. Clutches and brakes are similar, but the main difference between the two is that in a clutch, the input shaft and output shaft are initially connected, but in a brake, the brakepad and rotating part are first disconnected. connect. By pressing the brake pedal, oil squirts from the master cylinder and thus puts pressure on the brake caliper, which in turn applies braking force and slows the vehicle down. Finally, the brake and clutch conditions are switched. There are four types of clutches used in different applications. They are represented by figures 1, 2, 3, 4 and 5.

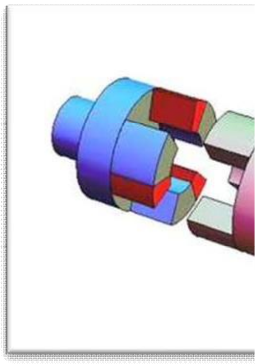

Figure 1: Square jaw clutch.

Figure 2: Electromagnetic clutch.

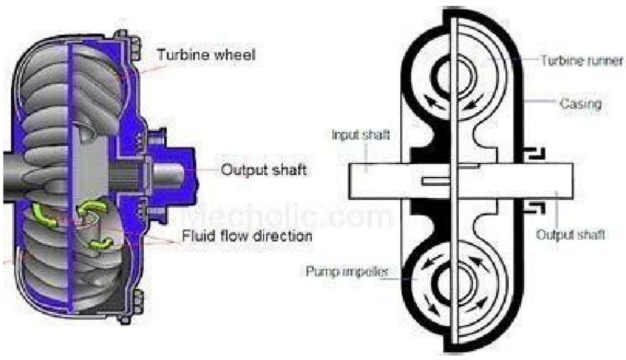

Figure 3. Fluid clutch

Figure 4. Single plate friction clutch

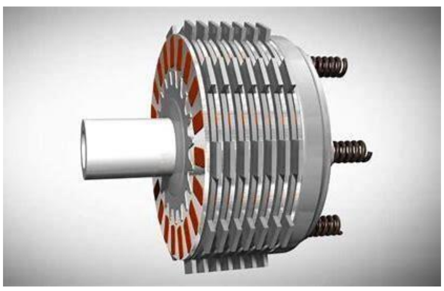

Figure 5: Multiplate friction clutch.

In this report we are dealing with the friction clutch. As seen above the friction clutches are divided into two types depending on the number of discs those two types are singleplate and multi plate

For designing of the clutch friction plate two theories are there: Figure 6 showsthe distribution of pressure vs the radius length.

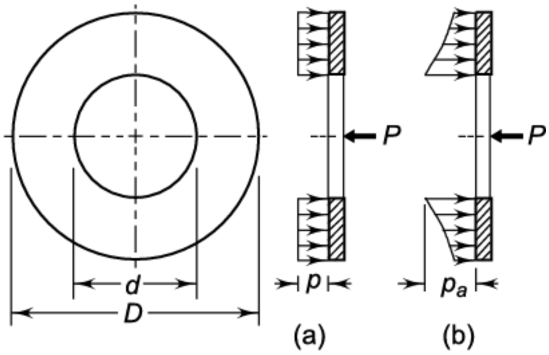

Figure 6: Pressure distribution.

- Uniform pressure.
- Uniform wear.

Uniform pressure theory

When using new clutches with several springs, the pressure is uniform throughout thefriction disk's whole surface. In uniform pressure theory

i. Torque capacity.

$$M_t = \frac{\pi\mu p}{12}(D^3 - d^3) \quad \text{- - - - - - - (1)}$$

ii. Operating force

$$P = \frac{\pi p}{4}(D^2 - d^2)$$

Uniform wear theory:

The uniform wear theory is applicable for new clutches only hence generallyuniform wear theory is considered while designing the clutches.

In uniform wear theory, p*r=constant

i. Torque capacity.

$$M_t = \frac{\pi\mu p_a d}{8}(D^2 - d^2) \quad \text{……….(3)}$$

$$M_t = \frac{\mu P}{4}(D+d) = \mu P \frac{1}{2}\left(\frac{D}{2} + \frac{d}{2}\right) = \mu P r_m \quad \text{……….(4)}$$

ii. Operating force:

$$P = \frac{\pi p_a d}{2}(D - d) \quad \text{…….(5)}$$

All title To design a clutch we need to follow a process. Step one. The basic method for designing aclutch is:

1. We need to find the specifications of the vehicle for which we are designing the clutch.
2. Material selection for various parts of the clutch.
3. Based on data. Note that the input data for the clutch design takes into account the safetyfactor
4. Decide what type of clutch we will design and choose the appropriate theory. Write theequations for the chosen method
5. Perform clutch size calculation
6. Based on the design, prepare a CAD model.
7. Perform analysis on the model and record conclusions.

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Figure 7: Royal Enfield Meteor 350

Specifications

We are designing a clutch for the "Royal Enfield Meteor 350". The specifications forthe vehicle are shown in Table 1

TABLE I: Specifications

Engine and Clutch	
Engine Type	Four stroke single cylinder SOCH 349 cc/ 21.22 cu-in
Max Engine Output	20.2hp/15kW @6100 rpm
Max Engine Torque	27 Nm/19.9 lb -ft @4000 rpm
Fuel Tank Capacity	15 L
Clutch	Wet multi plate.

Design Process for Material Selection

The material we choose to make the clutch disc is copper-based sintered metal with a coefficient offriction (μ = 0.1) on steel. The material of the pressure plate is steel. The allowable axial pressure for the clutch disc is 0.5 N/mm^2.

The choice of sintered metal for the clutch disc provides a comprehensive solution to the system requirements. clutch system. The high friction coefficient of the sintered metal ensures powerful torque transmission, facilitating smooth clutch engagement and release, thereby improving vehicleperformance. Additionally, the exceptional strength and wear resistance of sintered metal reduces clutch wear, extends component life and reduces maintenance needs, especially in heavy-duty vehicles or applications High performance. The thermal stability of the material dissipates heat effectively, protects the clutch from discoloration and ensures reliable operation at high temperatures. Its versatility spans the automotive, industrial and aerospace sectors, making it a versatile choice for various clutch applications. In essence, sintered metal represents a complete solution, balancing performance, durability, thermal stability, manufacturability and environmental considerations for optimal clutch performance. Table 2 shows some of the materials and their properties used for clutches.

TABLE II: Material properties

Material	Friction Coefficient. f	Maximum Pressure[psi]
Cement	0.32	150
Sintered metal (dry)	0.29-0.33	300-400
Sintered metal(wet)	0.06-0.08	500
Rigid molded asbestos(dry)	0.35-0.41	100
Rigid molded asbestos(wet)	0.06	300
Rigid molded asbestos pads	0.31-0.49	750
Semirigid molded asbestos	0.37-0.41	100
Flexible molded asbestos	0.39-0.45	100
Wound asbestos yarn and wire	0.38	100
Woven cotton	0.47	100
Resilience paper(wet)	0.09-0.15	400

The pressure plate provides the axial force to hold the clutch in the engaged position and requires a complex design. Hence 20 gray cast iron (FS). The clutch spring provides the axial force necessary for clutch engagement and operation. They are alsoused to reduce torque. Stainless steel with UNS number S030300 AISI number 303b would be suitable for the application. Table 3 shows the materials used for the springs

TABLE III: Spring Material

Material	Yield strength(MPa)	Ultimate tensilestrength (MPa)	Density (g/cm^2)
steel structuralASMT	250	400-550	7.8
Steel, 1090 mild	247	841	7.58
Chromium-vanadium steel	620	940	7.8
Steel 2800, maraging steel	2617	2693	8.00
Steel, AerMet340	2160	2430	7.86
Steel, stainless AISI 302	275	620	7.86

TABLE IV: Material properties

Parameter	Value	Units
Maximum Torque (Mt)	27000	N mm
Material	Bronze base sintered metal on steel	-
Coefficient of Friction (μ)	0.1	-
Service Factor (Ks)	1.2	-
Desired Maximum Torque ((Mt)des)	32400	N mm
Permissible Axial Pressure (Pa)	0.5	N/mm²
Outer Diameter (D)	100	mm

Here, the outer diameter of the clutch plate is already taken as 100mm because of thespace constrains

Type of Clutch and Selection of Theory

The clutch type is a multi-disc clutch in an oil bath. We chose a multi-plate clutch because most bikes use multi-plate clutches due to space constraints. But for four-wheeled vehicles, the clutch type is single disc because there is enough space. The theory used for the design is the uniform wear theory. There are two theories about clutch design. One is the uniform pressure theory where the pressure is uniform across the entire plate. Most of this theory is not used because it is only useful and valid for new clutches. As clutches age,the theory fails because after use, the pressure on the clutch disc changes with radius. Uniform wearing theory is mainly used in design because it has lasting value

According to the second theory, wear occurs uniformly over the entire surface of the friction disc. This statement is associated with a worn cover. The amount of frictional work is correlated with the axial reduction of the friction disc. Tangential speed (2πr n), where n is the speed in revolutions per minute (rpm) and the friction force (mp) is proportional to the energy wasted due to friction at a certain radius, denoted signal is r.In uniform wear theory p*r=constant.

Torque capacity

$$M_t = \frac{\pi \mu p_a d}{8}(D^2 - d^2)$$

$$M_t = \frac{\mu P}{4}(D + d) = \mu P \frac{1}{2}\left(\frac{D}{2} + \frac{d}{2}\right) = \mu P r_m$$

Operating force.

$$P = \frac{\pi p_a d}{2}(D - d)$$

The torque transmitting capacity can be increased by three ways:

Increasing the coefficient of friction.

Increasing the axial force.

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Increasing the mean radius.
The relation between d/D ratio and the torque capacity is shown.

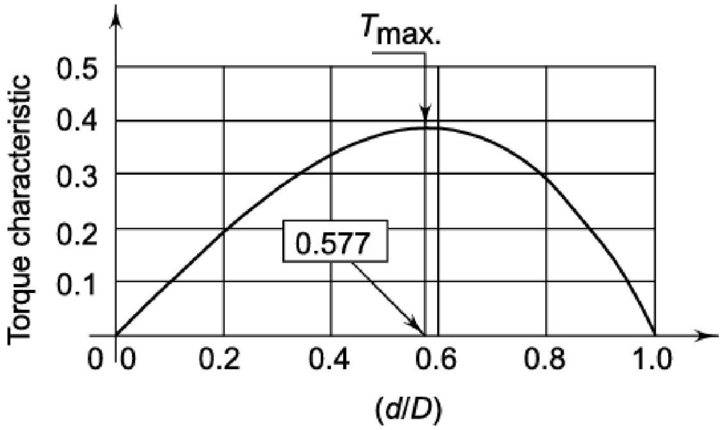

Fig 8: Variation of torque against d/D ratio.

Inside diameter of disc:
We are considering the condition of max torque transmission:d/D = 0.577

d = D * 0.577

d = 57.7 mm

d approximately equal to 58mm.

Total operating force:

$$P = \frac{\pi P_a d}{2}(D - d) = \frac{\pi(0.5)\ (58)}{2}(100 - 58)$$

$$= 1913.23 \text{ N}$$

Total number of discs required:

$$z = \frac{4Mt}{\mu P(D + d}$$

$$z = \frac{4*32400}{0.08*1913*(100+58)}$$

z = 5.35

take z = 6.

Hence the required number of discs = z+1 =6+1=7
Splines design:For splines
Do=120mm, Di=100mm, n=10

The torque transmitting capacity of splines is given by,

$$M_t = p_m A R_m \qquad (a)$$

where,

M_t = transmitted torque (N-mm)

p_m = permissible pressure on spline (N/mm^2)

A = total area of splines (mm^2)

R_m = mean radius of splines (mm)

32400/3= (0.5*(120-100) *l*10*(120+100))/8L= (32400*8)/ (0.5*20*10*220*3)
L=3.92, take L=4mm

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The excel sheet for the calculations is given:

TABLE V: Calculation for clutch DIMENSIONS

Symbol	Variable	Value	Unit
D_o	Outer diameter	100	mm
D_i	Inner diameter	58	mm
R_{mean}	Mean radius	39.5	mm
M_t	Torque	27000	N mm
K_s	Factor of safety	1.2	
$(M_t)_d$	Torque for design	32400	N mm
μ	Coefficient of friction	0.08	
P	Maximum permissible pressure	0.5	N/mm^2
Z	Number of pairs of contacting surfaces	6	
P	Total operating force	1913.2299	N

For engaging the clutch with the transmission force is required. This force is provided by the spring which are perpendicular to the plates. Hence, we design the spring also. The excel sheet for the spring is:

TABLE VII: Calculations for spring design

		Spring	
	Name and Symbol	Value	Unit
	material of spring	stainless steel	
G	modulus of rigidity	81370.00	N/mm^2
n	number of springs	4.00	
P	force per spring	478.31	N
σ	ultimate tensile strength	620.00	N/mm^2
δ	deflection in each spring	10.00	mm
C	spring index	5.00	
τ	permissible shear stress	310.00	N/mm^2
K	Wahl factor	1.31	
d	wire diameter	5.07	mm
D	mean coil diameter	25.37	mm
N	Number of active coils	9.00	
Nt	Number of coils	11.00	
g	Gap between two coils	1.00	mm
l	solid length	45.67	mm
L	free length	63.67	mm
p	pitch of the coil	4.79	mm
k	rate of spring	47.83	

III. MODELLING

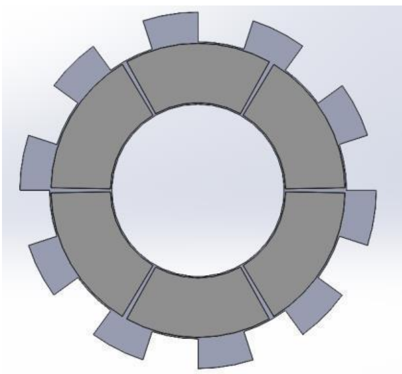

Figure 9: Friction plate

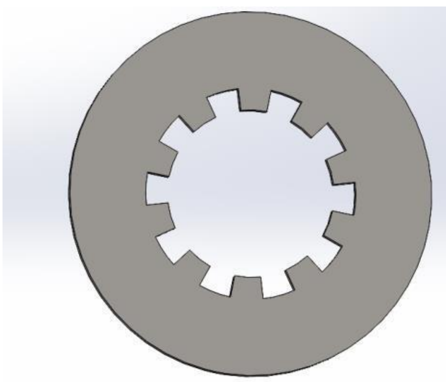

Figure 10: Pressure plate

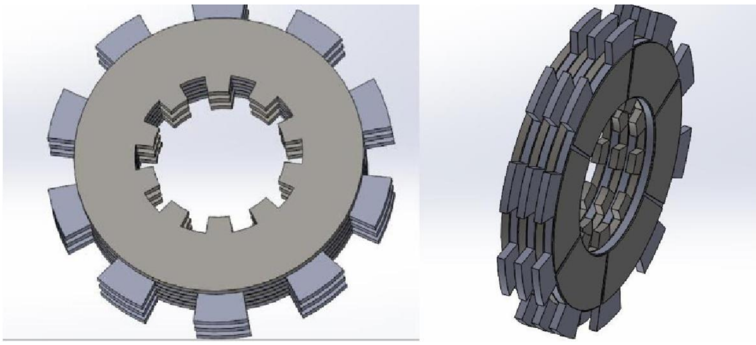

Figure 11: Assembly.

IV. ANALYSIS

Analysis is done in Ansys on the friction plate of the clutch. The method used is static structural.
For analysis one side face is fixed and other side is applied with axial pressure due to the spring.
We are considering the max pressure. The value of pressure is calculated by. p = operating force/Ares
p=1913.23/20847.60
Hence, p = 0.091 N/mm

a) Meshing: The details of the meshing are shown in figure 12 and Table 8

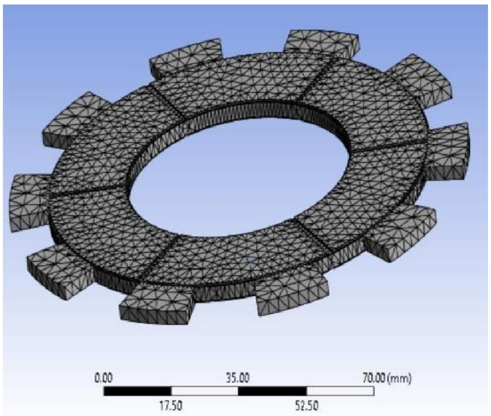

Figure 12: Mesh diagram.Table 8: Mesh Details

TABLE VIIII: Mesh details

Display	
Display style	Use Geometry Setting
Defaults	
Physics preference	Mechanical
Element Order	Program Controlled
Element size	3.0 mm
Sizing	
Use Adaptive sizing	Yes
Resolution	Default [2]
Mesh Defeaturing	Yes
Defeature size	Default
Transition	Fast
Span angle center	Coarse
Initial size seed	Assembly
Bounding box diameter	169.75 mm
Average Surface Area	155.29mm^2
Minimum Edge Length	0.5 mm

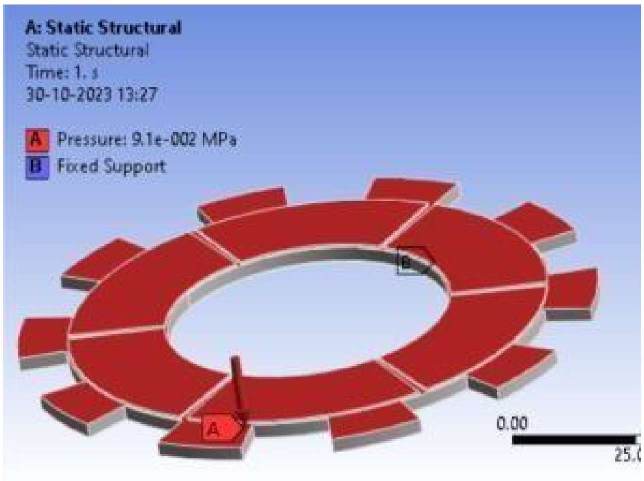

Figure 13: Boundary conditions

V. RESULTS AND DISCUSSION

The results of the analysis are:

The analysis we performed in ANSYS on the static structure to find the actual stress induced in the clutch and the deformation obtained in design mode in SolidWorks. All the stresses induced in the body were found to be lower than the maximum allowable stress of the material taken from the data sheet. In the stress analysis of the friction plate, the results were obtained as follows :

TABLE VIVII: Results for design of clutch

Dimension/Parameter	Value	Units
Outer Diameter of Clutch	100	mm
Inner Diameter of Clutch	58	mm
Total Number of Contacting Surfaces	6	-
Total Number of Plates	7	-
Total Operating Force	1913	N
Number of Springs	4	-

TABLE IX: Ansys Results for Stress Analysis

Parameter	Maximum value	Units
Maximum Deformation	0.0000187	mm
Maximum Equivalent Stress	0.1562	N/mm^2
Maximum Shear Stress	0.049176	N/mm^2
Maximum Normal Stress	0.20076	N/mm^2

ANSYS analysis are shown in figure 14.

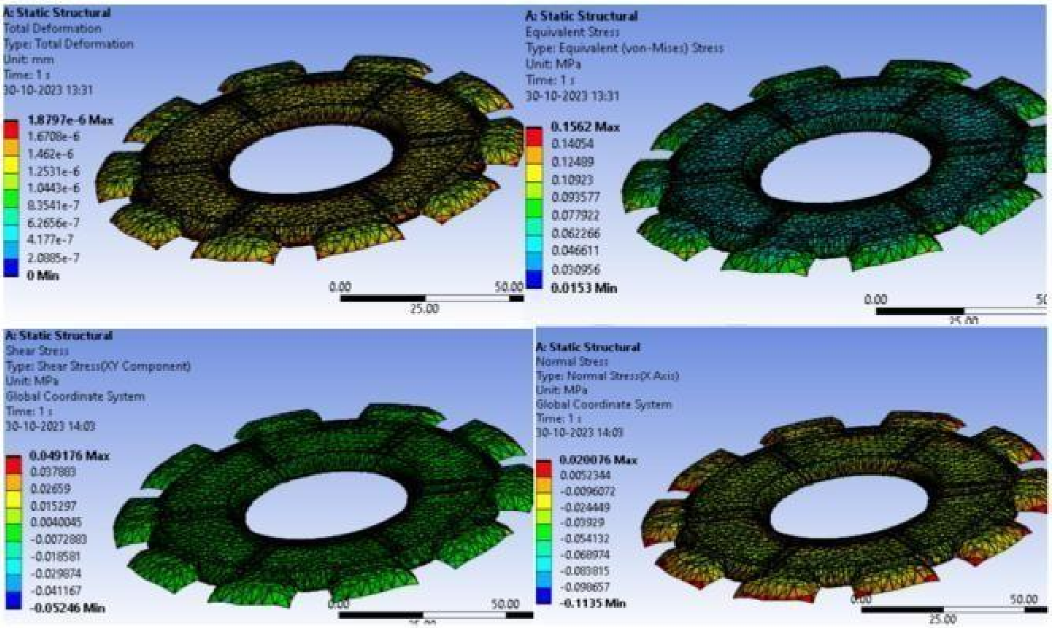

Figure 14: Total deformation, Equivalent stress, Shear stress, Normal stress

VI. CONCLUSION

In conclusion, this research paper has provided an in-depth study of the design and analysis of multi-plate clutch systems in automotive applications. Through a comprehensive review of design techniques, challenges and advances, key factors such as contact characteristics, thermal management, structural integrity and material selection have been explored. The integration of multi-plate clutch systems with hybrid powertrains and the implications of the electrification trend are also discussed. By addressing these important aspects and identifying areas of future research, this paper contributes to the advancement of automotive engineering, promoting innovations that improve efficiency, effectiveness, and efficiency. performance and durability of modern vehicles. We hope that the information presented here will inspire further research and development in this important area, ultimately leading to improved clutch systems and improved driving experiences.for consumers worldwide. The proposed design can withstand a maximum equivalent stress of 0.1562N/mm2 and the maximum shear stress is found to be 0.049176N/mm2. The proposed design is said to have a deformation of 0.0000187 mm and can withstand a maximum nominal stress of 0.2N/mm2.

VII. ACKNOWLEDGMENT

The heading of the Acknowledgment section and the References section must not be numbered. Causal Productions wishes to acknowledge Michael Shell and other contributors for developing and maintaining the IEEE LaTeX style files which have been used in the preparation of this template.

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