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Modeling, Assembly and Structural Analysis of a Multi Plate Clutch by Using Fea Approach Software

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ABSTRACT

Multi plate clutch is one of the important parts 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 project, we have 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.

This paper conducted structural analysis by varying the friction surfaces material and keeping base material as Steel. By observing the results, comparison is done for materials to validate better lining material for multi plate clutch by doing analysis on clutch with help of ANSYS Workbench software and FEM to find out which material is best for the lining of friction surfaces.

KEYWORDS: Multi-plate clutch, Friction material, ANSYS, CATIA V5

1. 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 forgear selection and then again engaged smoothly to power the vehicle.

Generally, there are twotypes 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.

1.2 PARTS of Multi plate clutch

The following are the major parts of a multi-plate cone:

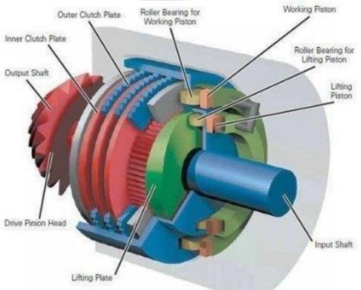


Fig 1: major parts of a multi-plate cone:

2. OBJECTIVES

1. Understand research problem and gain knowledge of previous research findings.
2. Design multi plate clutch-plate interface dynamometer (MCID), produce engineering drawings and for manufacture.
3. Develop heat transfer model to gain understanding of influence of system and material properties on clutch plate friction surface temperatures.
4. Develop fully thermos-mechanically coupled finite element models of a Multi clutch plate pair under MCID operating conditions in order to predict clutch plate temperatures and extent of hot banding
5. 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 increase in number of friction surfaces obviously increases the capacity of clutch to transmit torque

3. MATERAILS

3.1 ALUMINIUM ALLOY

Aluminium-Silicon (Al-Si) alloys are most flexible materials, comprising 85% to 90% of the total aluminium shed parts produced for the automotive industry. Depending on the Si focus in weight percent (wt. %), the Al-Si alloy systems drop into three major categories: hypoeutectic (<12% Si), hypereutectic (14-25% Si) and eutectic (12-13% Si)

However, most Al-Si alloys are not suitable for lowering temperature applications because tensile and fatigue strengths are not as high as preferred in the temperature range of 500 - 700 °F .

Typical alloying elements are with copper (1.31%), zinc (0.494%), magnesium (1.05%), silicon (10.9%), manganese (0.494%), chromium (0.35%), titanium (0.15%), aluminium (83.39%) and iron is invariably present in small quantities.

Advantages of Aluminum Matrix Composites Over iron, steel and other non-ferrous metals are as follows:

- Higher elevated temperature strength
- Improved wear resistance
- Low density; high strength to weight ratio
- Improve damping capabilities
- Good corrosion resistance

3.2 MAGNESIUM ALLOY

Magnesium alloys are well-known for being the lightest structural alloys. They are made of magnesium, the lightest structural metal, mixed with other metal elements to improve the physical properties. These elements include manganese (0.246%), aluminium (6.18%), zinc (0.99%), silicon (0.033%), copper (0.0032%), rare-earth metals (1.33%) and magnesium (91.22%).

Some of magnesium's favourable properties include low specific gravity and a high strength to-weight ratio. As a result, the material lends itself to a range of automotive, aerospace, industrial, electronic, biomedical, and commercial applications.

Here, you can learn about the various types of magnesium alloys and their designations, the physical properties of magnesium alloys, and the applications in which magnesium alloys are used.

- Lightweight

- Low density (two thirds that of aluminium Good high-temperature mechanical
- properties Good to excellent corrosion resistance

4. MODELLING OF MULTI PLATE CLUTCH

There are different modules in CATIA using which different tasks can be performed. The main window and modules of CATIA shown in figure

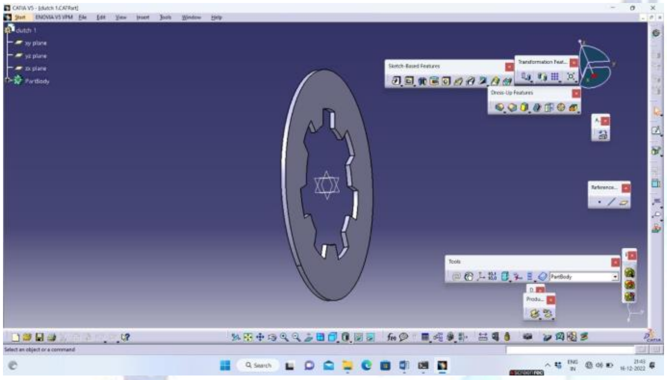


Fig.2: Pressure Plate

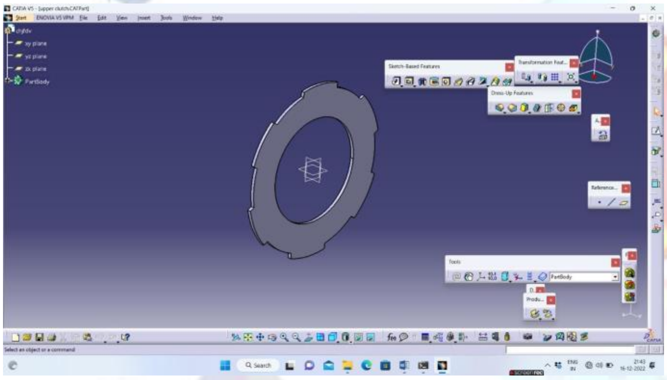


Fig.:3: Friction Clutch

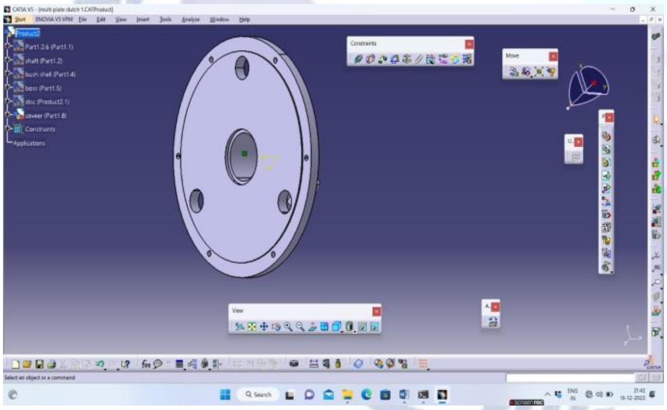


Fig.4: Clutch Boss

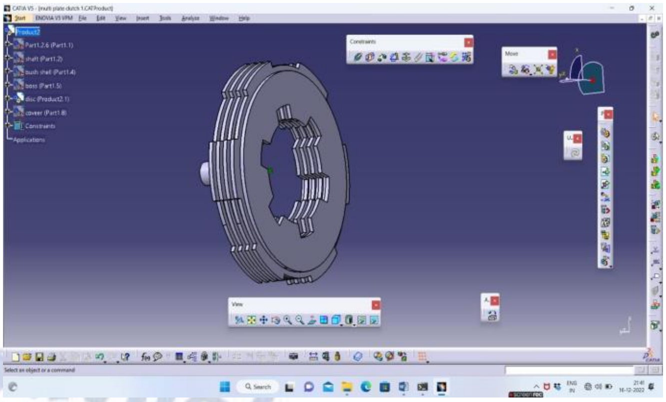


Fig5: Assembly of plates

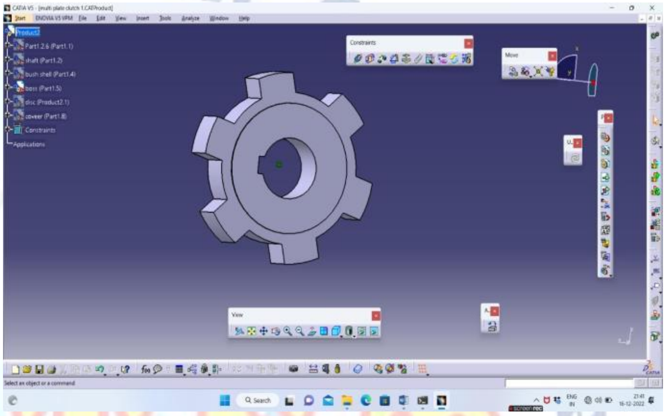


Fig.6: Gear Rotor

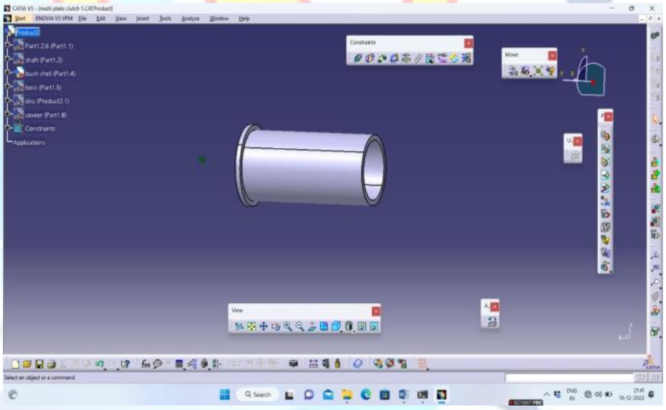


Fig.7: Bush for Boss

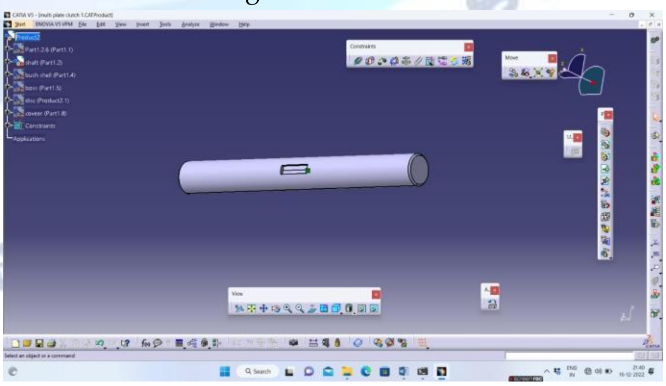


Fig.8: Shaft

4.1 Assembly of multiplate clutch

CATIA enables the creation of 3D parts, from 3D sketches, sheet metal, composites, and molded, forged or tooling parts up to the definition of mechanical

assemblies. The software provides advanced technologies for mechanical surfacing & BIW. It provides tools to complete product definition, including functional tolerances as well as kinematics definition. CATIA provides a wide range of applications for tooling design, for
both generic tooling and mold & die.

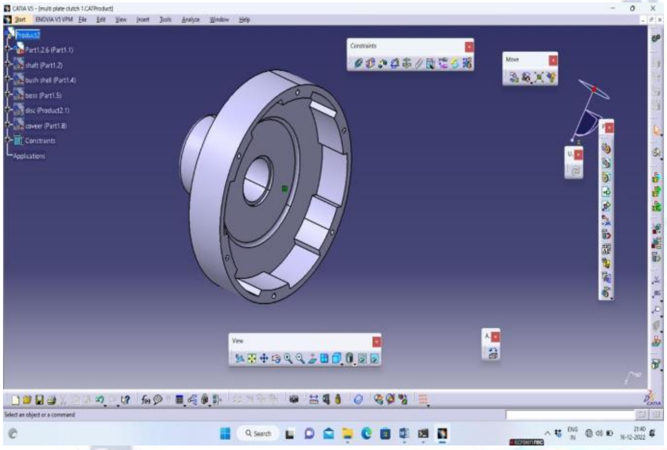


Fig.9: Clutch Housing

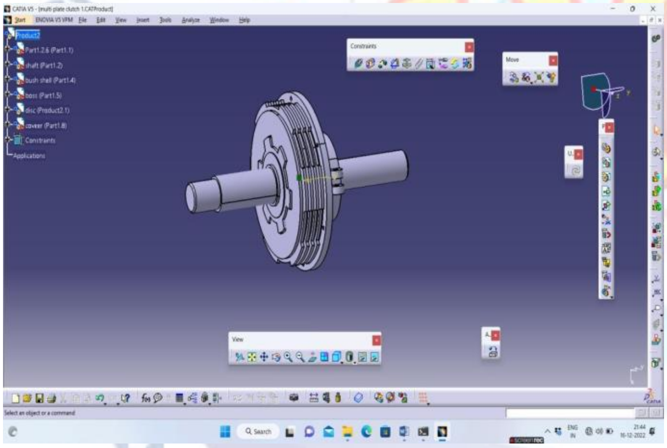


Fig.10: Assembly of clutches and shaft

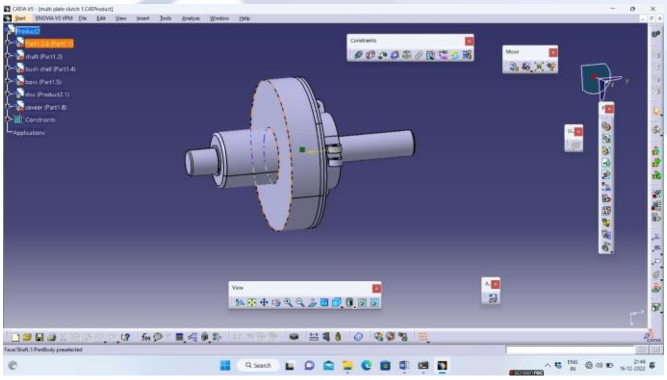


Fig.11: Modeling of multi plate clutch

5. Results and Analysis

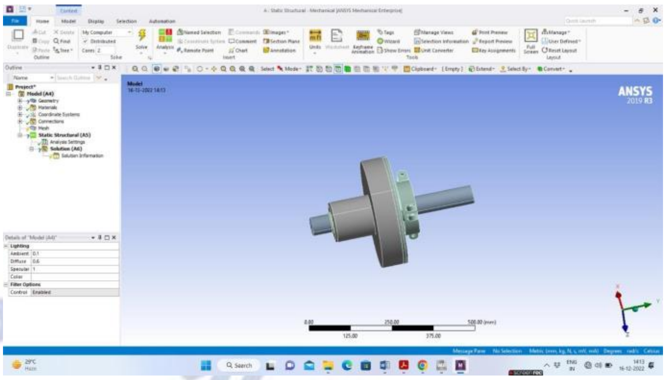


Fig.12: Imported from Catia V5

5.1 MESHING:

MESHING: Before lattice the model and even before building the model, it is essential to consider whether a free work or a mapped cross section is proper for the examination.

A free work has no limitations as far as component shapes and has no predefined example
connected to it. Contrast with a free work, a mapped cross section is confined as long as the component shape it contains and the pattern of mesh. Mapped area mesh contains either quadrilateral or just triangular components, while a mapped volume cross section contains just hexahedron components. In the event that we need this kind of lattice, we must form the geometry as arrangement of genuinely normal volumes and/or regions that can acknowledge
a mapped network

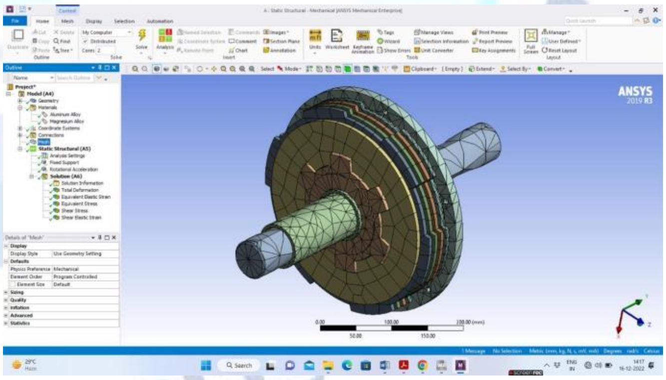


Fig.13: Meshing of multi plate clutch

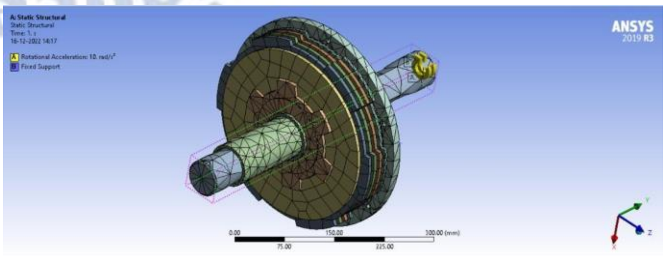


Fig.14: Boundary conditions

5.2 Results of ALUMINIUM ALLOY

Aluminum Alloy

General aluminum alloy. Fatigue properties come from MIL-HDBK-5H, page 3-277.

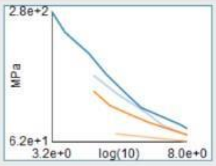
Density	2.77e-06 kg/mm³
Structural	
Isotropic Elasticity	
Derive from	Young's Modulus and Poisson's Ratio
Young's Modulus	71000 MPa
Poisson's Ratio	0.33
Bulk Modulus	69608 MPa
Shear Modulus	26692 MPa
Isotropic Secant Coefficient of Thermal Expansion	2.3e-05 1/°C
Compressive Ultimate Strength	0 MPa
Compressive Yield Strength	280 MPa
S-N Curve	
Tensile Ultimate Strength	310 MPa
Tensile Yield Strength	280 MPa

Table 1: Material properties of aluminium alloy

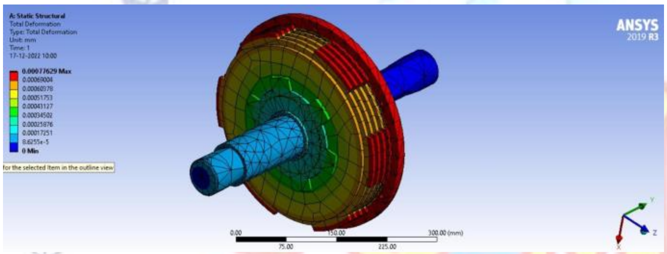


Fig.15: Total deformation

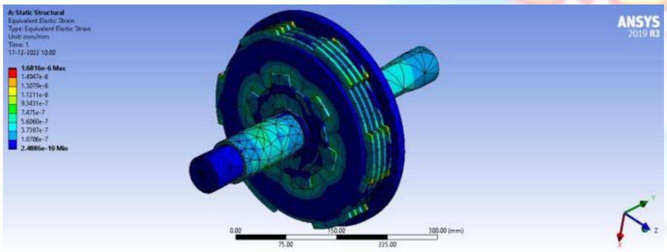


Fig.16:Equivalent elastic strain

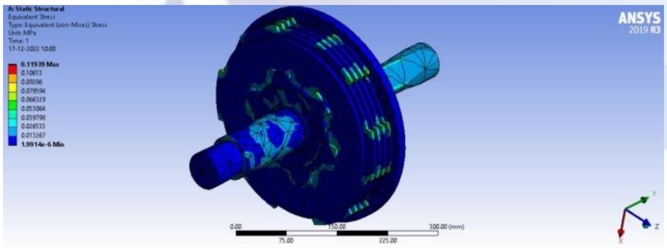


Fig.17:Equivalent stress

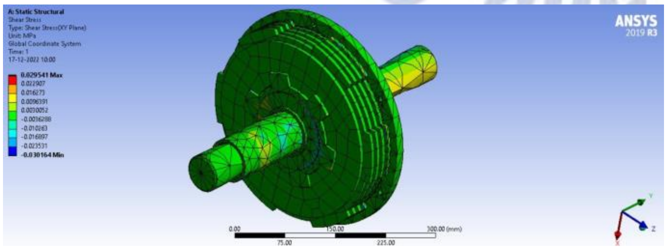


Fig.18: Shear stress

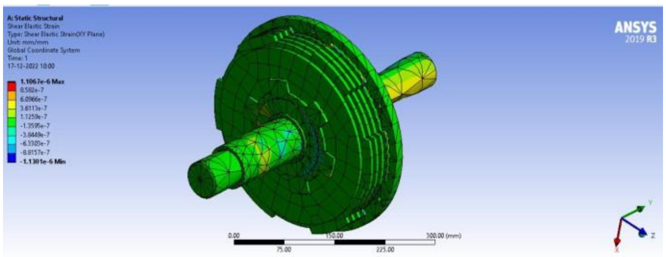


Fig.19: Shear elastic strain

5.3 Results of Magnesium Alloy

Magnesium Alloy

Density	1.8e-06 kg/mm³
Structural	
Isotropic Elasticity	
Derive from	Young's Modulus and Poisson's Ratio
Young's Modulus	45000 MPa
Poisson's Ratio	0.35
Bulk Modulus	50000 MPa
Shear Modulus	16667 MPa
Isotropic Secant Coefficient of Thermal Expansion	2.6e-05 1/°C
Compressive Ultimate Strength	0 MPa
Compressive Yield Strength	193 MPa
Tensile Ultimate Strength	255 MPa
Tensile Yield Strength	193 MPa
Thermal	
Isotropic Thermal Conductivity	0.156 W/mm·°C
Specific Heat Constant Pressure	1.024e+06 mJ/kg·°C
Electric	
Isotropic Resistivity	0.00077 ohm·mm

Table 2: Material properties of magnesium alloy

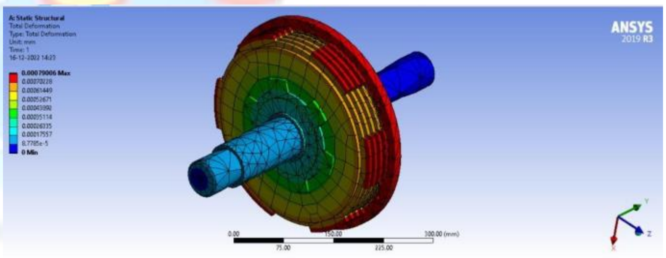


Fig.20: Total deformation

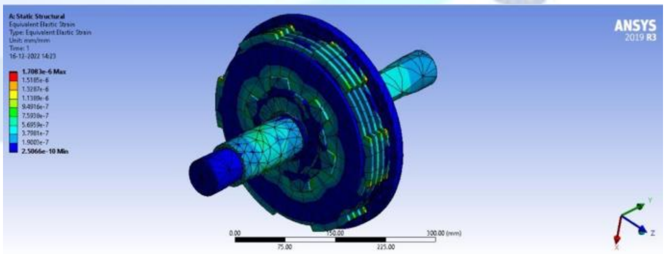


Fig 21: Equivalent elastic strain

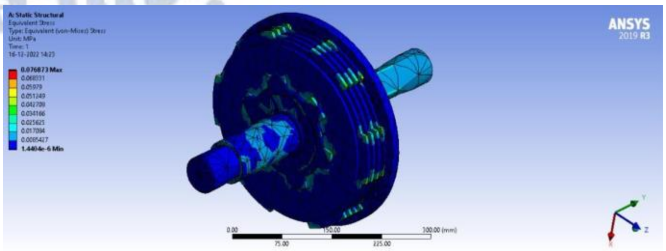


Fig.22: Equivalent stress

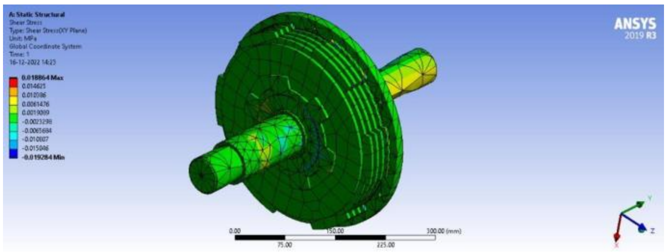


Fig.23: Shear stress

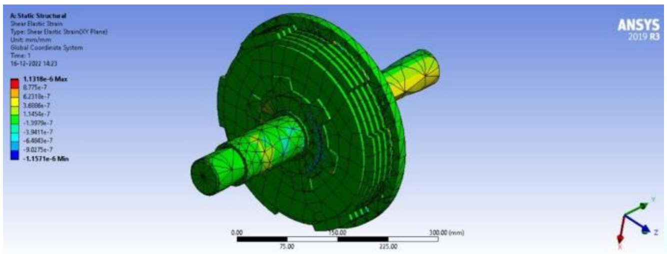


Fig.24: Shear elastic strain

Results	Minimum	Maximum	Units	Time (s)
Total Deformation	0.	7.7629e-004	mm	1.
Equivalent Elastic Strain	2.4886e-010	1.6816e-006	mm/mm	1.
Equivalent Stress	1.9914e-006	0.11939	MPa	1.
Shear Stress	-3.0164e-002	2.9541e-002	MPa	1.
Shear Elastic Strain	-1.1301e-006	1.1067e-006	mm/mm	1.

Table 3: Material Properties of aluminium alloy

Results	Minimum	Maximum	Units	Time (s)
Total Deformation	0.	7.9006e-004	mm	1.
Equivalent Elastic Strain	2.5066e-010	1.7083e-006	mm/mm	1.
Equivalent Stress	1.4404e-006	7.6873e-002	MPa	1.
Shear Stress	-1.9284e-002	1.8864e-002	MPa	1.
Shear Elastic Strain	-1.1571e-006	1.1318e-006	mm/mm	1.

Table 4: Results of magnesium alloy

6. CONCLUSION

In this project the clutch plate has been designing by using cad tool CATIA and then importing into CAE tool (ANSYS Work Bench).

From the ANSYS Workbench structural simulation and analysis in FEM is a key to facilitate the assessment of structural analysis of clutch plate which provides relatively simple method for analysing of material strength. Besides, the analysis shows that increase in tensile yield strength of material, the maximum equivalent stress decrease and similarly the deformation rate decreases. The final result shows that Aluminium alloy materials have low deformation in their applied load and pressure conditions than other materials used, it also has high wear resistance property and lower weight than existing Magnesium alloy materials.

Conflict of interest statement

Authors declare that they do not have any conflict of interest.

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