DESIGN AND ANALYSIS OF MULTI PLATE CLUCH USING VARIOUS MATERIALS

[1]Dr.B.V.Krishnaiah, [2]N.Chenna Reddy, [3]V.Vamsi Krishna, [4]P.Masthan, [5]D.Abhishek
[1]Professor & HOD of ME Department, Narayana Engineering College, Gudur, Tirupati
[2]Student, [3]Student, [4]Student, [5]Student, Narayana Engineering College, Gudur, Tirupati

Abstract: Multi plate clutch is important part mostly used in racing cars and heavy-duty vehicles for obtaining high torque outputs. The design of the multi plate clutch is created in Solid Works, and imported in Ansys workbench for transient structural analysis, by varying the friction surfaces material, A design overview of the transmission of multi plate clutch, main characteristics, key subsystems and control strategies. By all of this gives you better understanding about working principle of clutch, material used for making the clutch plates. Effect of design consideration can be further studied during its application in various conditions the result of materials is depend on transient structural analysis - stress, total deformation and strain of the friction plate. For analysis conducting a materials like aluminium alloy high carbon steel and carbon fiber. Compare the results of material and select the best material based on results obtained in transient structural analysis.

Keywords: *Multi plate clutch, CATIA, ANSYS Workbench 19.2, Structural Analysis.*

INTRODUCTION

A multi-plate clutch is a mechanical device used in automotive and industrial applications to transmit power from the engine to the transmission system. It is a highly efficient and reliable type of clutch that utilises multiple friction plates to engage and disengage the power flow. The design of a multi-plate clutch allows for smoother engagement, better heat dissipation, and higher torque capacity compared to single-plate clutches. With its ability to handle heavy loads and provide precise control over power transmission, the multi-plate clutch plays a critical role in ensuring smooth gear shifting and efficient power transfer in various vehicles an A multi-plate clutch is a sophisticated mechanism used in various automotive and industrial applications to efficiently transfer power between rotating shafts. Its design typically consists of multiple friction plates interleaved with smooth steel plates, all housed within a clutch assembly. When engaged, hydraulic or mechanical pressure forces the friction plates against the smooth plates, creating friction and allowing power to be transmitted from the engine to the transmission system. Multi-plate clutches offer advantages such as high torque capacity, compact size, and smooth engagement, making them ideal for high-performance vehicles, heavy machinery, and other demanding applications where precise control and durability are essential.

METHODOLOGY

Finite Element Analysis (FEA) is a numerical technique used to analyse complex structures or systems by dividing them into smaller, simpler elements. These elements are interconnected at discrete points called nodes. FEA solves equations governing the behaviour of each element to predict the overall behaviour of the entire system. It's widely used in engineering and physics for simulating structural, thermal, fluid flow, and electromagnetic problems.

Discretization: FEA discretizes the continuous problem domain into a finite number of elements, often triangles or quadrilaterals in 2D and tetrahedra or hexahedra in 3D.

Element formulation: Each element is defined by a set of mathematical equations describing its behaviour. These equations typically relate physical quantities like stress, strain, displacement, temperature, etc.

Assembly: The equations for all elements are assembled into a system of algebraic equations, which represents the behaviour of the entire system.

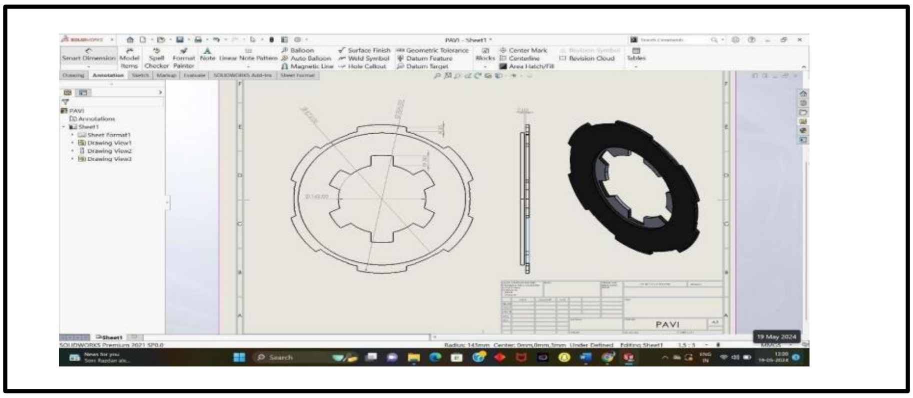
Solution: The system of equations is solved numerically using methods like direct solvers, iterative solvers, or specialized algorithms like conjugate gradient method.

Post-processing: Once the solution is obtained, engineers analyse and interpret the results. This may involve visualizing stress distributions, deformation patterns, temperature gradients, etc.

I. CAD MODEL

CAD model of existing multi plate clutch has been prepared in CATIA as shown in figure, the dimensions were measured from existing connecting rod.

2D-DRAFTING



3.1 ANALYSIS OF MULTI PLATE CLUTCH:

Generate a finite element mesh. The mesh quality can significantly impact the accuracy of the results. Ensure an adequate number of elements in critical areas (stress concentrations, complex geometry). The sensitive regions have been re-meshed manually considering the shape and size of the parts.

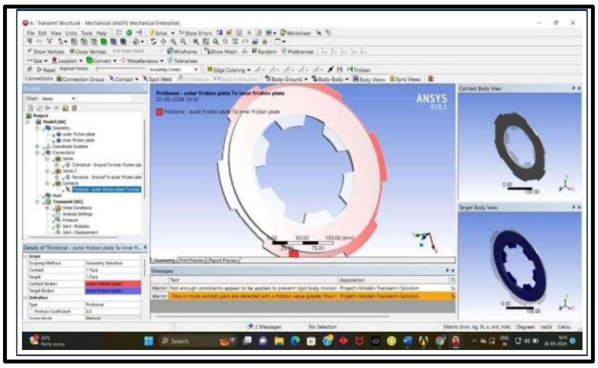


Fig-1: Before meshing

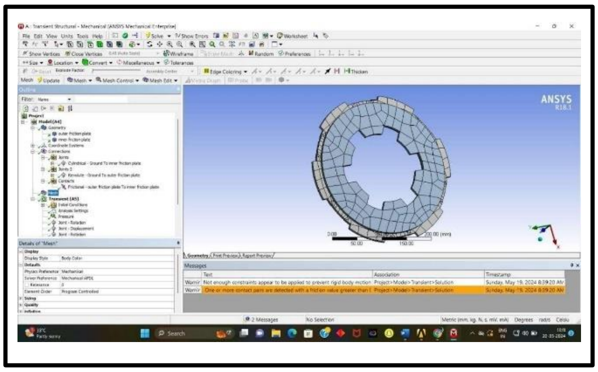


Fig-2: Meshed model

3.2 LOADING CONDITIONS:

The accurate thermal analysis of a multi plate clutch requires a comprehensive understanding of the thermal and mechanical loads it experiences during operation. By considering the conditions, engineers can predict the performance, identify potential failure modes, and optimize the design for better durability and efficiency.

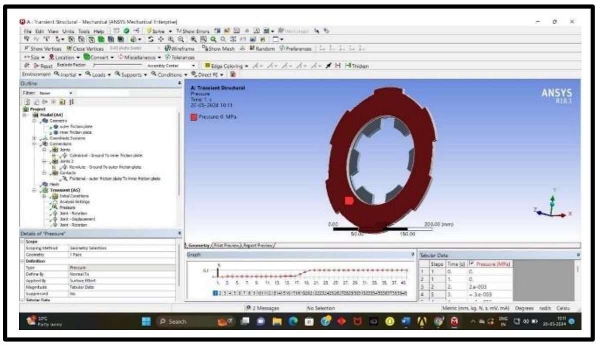


Fig-3: Loading Conditions

3.3 MATERIALS USED:

3.3.1 ALLUMINIUM ALLOY

Alluminium alloys are alloys that contain a mixture of titanium and other chemical elements. Such alloys have very high tensile strength and toughness even at extreme temperatures. They are light in weight, have extra ordinary corrosion resistance and the ability to withstand extreme temperatures.

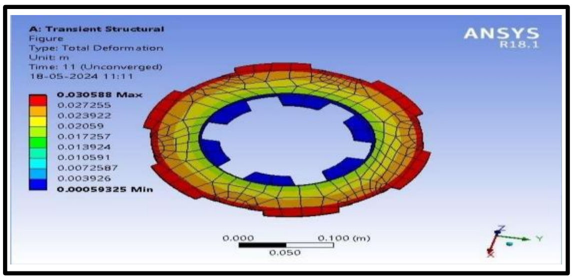


Fig 1: Total deformation

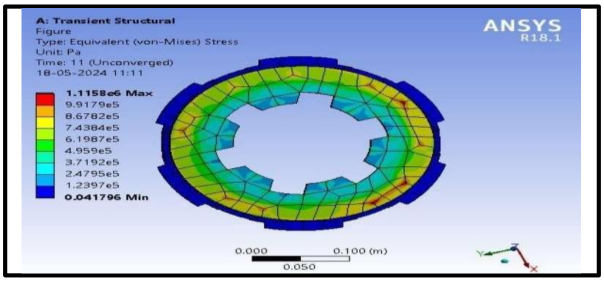


Fig 2: Equivalent stress

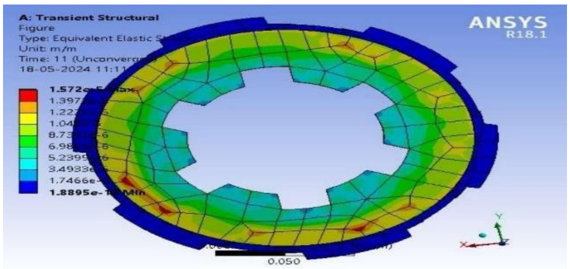


Fig 3: Equivalent strain

3.3.2 HIGH CARBON STEEL:

High carbon steel are mixtures of magnesium the lightest structural metal with other metals, often aluminum, zinc, manganese, silicon, copper, rare earths and zirconium. High carbon steel have a hexagonal lattice structure, which affects the fundamental properties of these alloys. Plastic deformation of the hexagonal lattice is more complicated than in cubic latticed metals like aluminum, copper and steel; therefore, magnesium alloys are typically used as cast alloys, but research of wrought alloys has been more extensive.

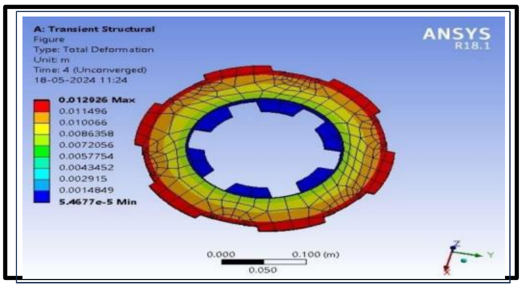


Fig 1 Total deformation

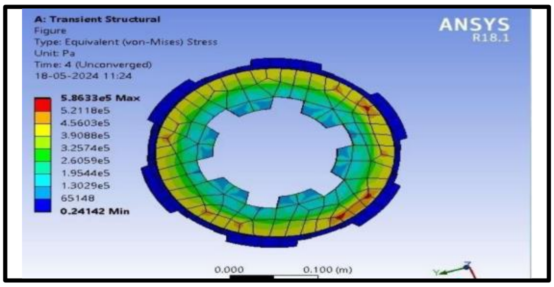


Fig 3 : Equivalent stress

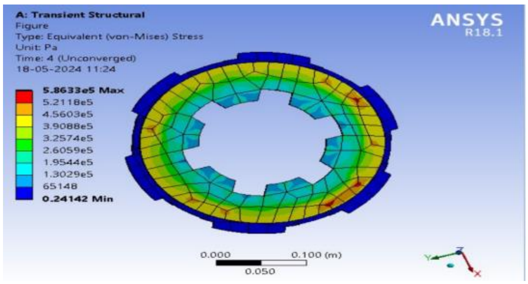


Fig 3: Equivalent elastic strain

CARBON FIBER

Carbon fiber is a category of steel used for making construction materials in a variety of shapes. Many structural steel shapes take the form of an elongated beam having a profile of a specific cross section. Structural steel shapes, sizes, chemical composition, mechanical properties such as strengths, storage practices, etc., are regulated by standards in most industrialized countries.

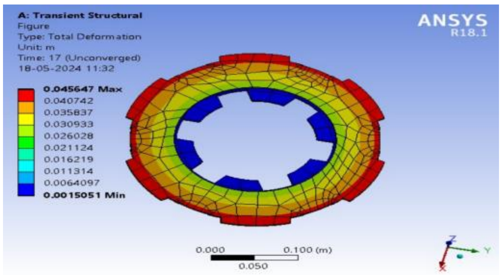


Fig 1: Total deformation

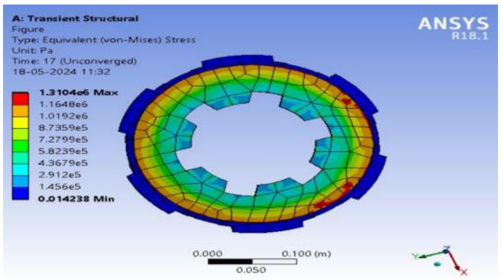


Fig 2: Elastic stress

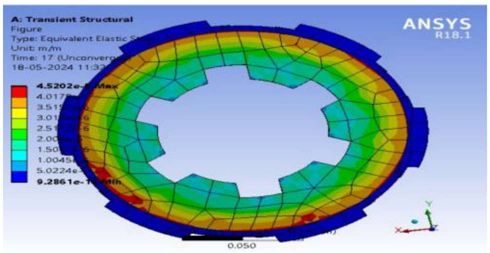


Fig 3: Equivalent elastic strain

II. ANALYSIS RESULTS

1. Total deformation:

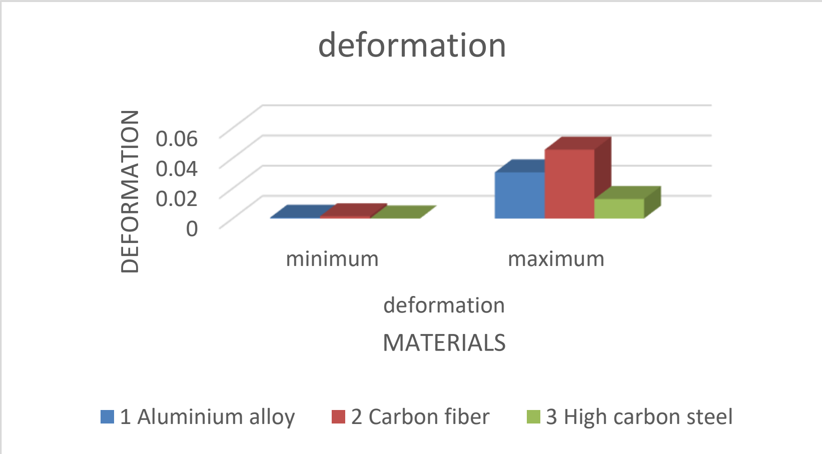


Fig 4.1Total deformation graph

2. Equivalent stress :

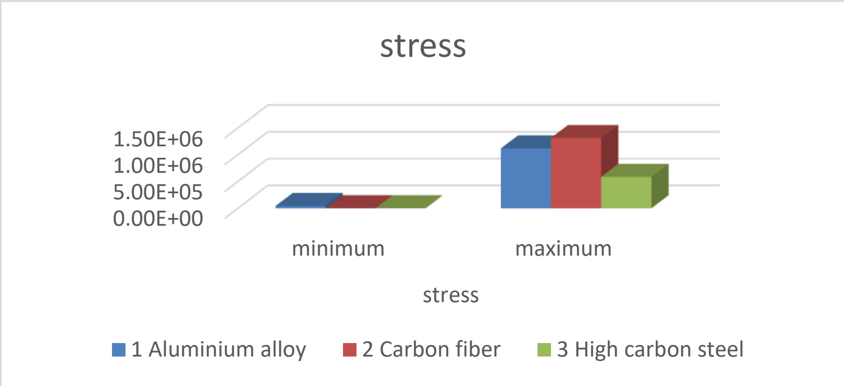


Fig 4.2 – Equivalent stress graph

3. Equivalent strain:

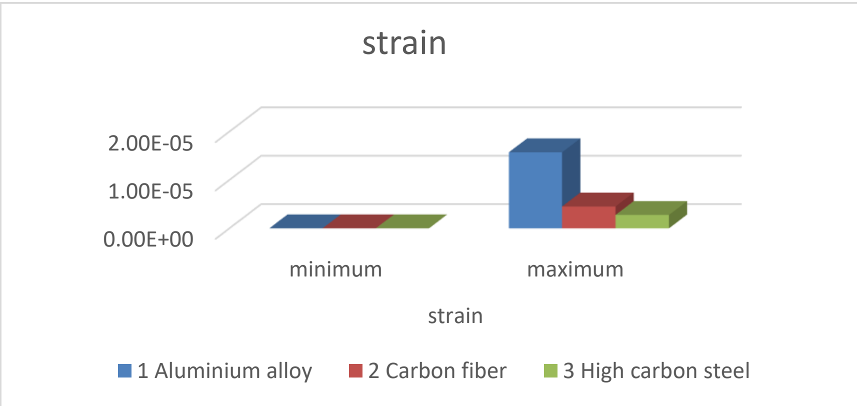


Fig 4.3 – Equivalent elastic strain graph

Comparison Table:

Materials	Total deformation	Equivalent stress	Equivalent elastic strain
Alluminium alloy	0.00059325 m	0.041796 m	1.8895e-12
High carbon steel	5.4677e-5	0.24142 pa	1.1489e.12
Carbon Fibre	1.3004e-3m	1.4238e-2 pa	9.2861e-14

CONCLUSION

Project Objective Recap:

- The project aimed to analyse the performance of different friction materials—aluminium alloy, high carbon steel, and carbon fibre in a multi-plate clutch design through transient structural analysis in ANSYS Workbench
- The multi-plate clutch was first designed in SolidWorks to ensure accurate representation of the system.
- The design was then imported into ANSYS Workbench for transient structural analysis.

Material Comparison Results:

- High carbon steel exhibited the least total deformation among the tested materials.
- Aluminium alloy showed higher deformation than high carbon steel but less than carbon fibre.
- Carbon fibre had the highest total deformation values.
- Considering the overall performance metrics, high carbon steel emerges as the optimal material choice for the friction plates of the multi-plate clutch.

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