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Design and Analysis of Single Plate Friction Clutch

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Abstract **- This paper presents the stresses and deformations of the automotive single plate clutch depending on the applied materials. In design of the friction clutches of automobiles, knowledge on the thermo-elasticity a priori is very informative in the initial design stage. Especially, the precise prediction technique of maximum structural stress should be requested in design of mechanical clutches for their durability and compactness. Structural analysis of the clutch was performed by using the finite element method for a repressive vehicle example - TATA Sumo. First, the input data for the numerical analysis was calculated. Numerical analysis was performed in the ANSYS software package. As a result, the values of stresses and deformations that occur on the clutch during the vehicle exploitation are obtained. 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 kevlar and asbestos are taken. A single plate clutch is designed and modeled using Solid works 2018 software. Static analysis is done on the clutch to determine stresses and deformations using materials Ceramic, cast iron alloy, asbestos, sintered metal, kevlar and cermet. Analysis is done in Ansys 2021(R1) version. Theoretical calculation are also done to determine stresses.**

Index Terms **- Clutch, stress, deformation, material, ANSYS, vehicle exploitation, static analysis, solid works.**

1.INTRODUCTION

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. However, the slipping mechanism of the clutch generates heat energy due to friction between the clutch disc and the flywheel.

Clutch works on the principle of friction. When two friction surfaces are brought in contact with each other and pressed they are united due to the friction between them. [1]

The friction between the two surfaces depends upon the area of the surfaces, pressure applied on them and co-efficient of friction of the surface material. The two surfaces can be separated and brought into contact when required.

One surface is considered as a driving member the other as a driven member. The driving member is kept rotating, when the driven member is brought in contact with the driving member it also rotates. When the driven member is separated from the driving member it does not rotate. [2]

Figure 1 – Parts of clutch assembly [3]

2. LITERATURE SURVEY

Clutch is one of the essential components in automobiles. It is located between the engine and the gear box. The main function of the clutch is to initiate the motion or increase the velocity of the vehicle by transferring kinetic energy from the flywheel. The present paper deals with the designing and analysis of friction clutch plate. Design has done by using

Solid works software and static structural analysis carried by using ANSYS. Finally, the plots for equivalent stress and total deformations were obtained for different friction materials for friction clutch plat, Uniform wear theory were used for the analysis.

Clutch is a mechanical device, which is used to engage or disengage the source of power from the rest of the power transmission system at the operator's will.

Clutches are designed to transfer maximum torque with minimum heat generation. During engagement and disengagement, the two clutch discs has the sliding motion between them.

The research shows that that designing and analysis of single plate friction clutch. In the analysis part the model are analyzed with different materials by conducting analysis which are structural. Structural analysis is done to find out the stress values. By this analysis result we are suggesting the best material to the effective model of the single plate friction clutch. [4]

Figure 2 – Single Plate Clutch [5]

3. CONCLUSION FROM LITERATURE REVIEW

From the above literature survey we found that structural analysis will be performed on the single plate friction clutch. The various factors such as: - Material has less deformation, high coefficient of friction and High wear resistance on the lining of friction plate due to seizure between the friction plate and the mating surface.

Then, We have decided that we will do the analysis by taking the materials such as Ceramic, cast iron alloy, asbestos, sintered metal, kevlar and cermet and find out the total deformation, maximum stress and compare the results and chose the best available material for friction lining.

3.1PROBLEM STATEMENT

In vehicles there are one or more friction discs that are joined together or pressed against a flywheel using springs. Clutch plates found in trucks and speed cars are made of ceramic. When the clutch pedal is depressed the spring pressure is released pushing or pulling the diaphragm of the pressure plate. Thus, the friction plate is released and allowed to rotate freely. The clutch plate is used to increase or decrease the speed of a vehicle. However, increasing the engine speed too high engages the clutch. This, in turn, causes excessive clutch plate wear due to loading condition the pressure contact between the contact surfaces that occurs due to the axial force applied the diaphragm spring.

4.METHODOLOGY

The lining material should have a combination of the following properties to withstand the operating conditions [6]

- Relatively high coefficient of friction under entire operating conditions.
- Maintenance of friction properties during entire working life.
- Relatively high energy absorption for short periods.
- Withstanding high pressure plate compressive loads.
- Withstanding high impacts of centrifugal force during gear changing.
- Adequate shear strength to transmit engine torque.
- High level of endurance in cyclic working without effecting friction properties.
- Good compatibility with cast iron facings over the entire range of operating temperature.
- A high degree of tolerance against interface contamination without affecting its friction take up and grip characteristics.

Considerations in Designing of a Friction Clutch

- The following considerations must be kept in mind while designing a friction clutch. The suitable material forming the contact surfaces should be selected.
- The moving parts of the clutch should have low weight in order to minimize the inertia load, especially in high-speed service.
- The clutch should not require any external force to maintain contact of the friction surfaces.
- The provision for taking up wear of the contact surfaces must be provided.
- The clutch should have provision for facilitating repairs.
- The clutch should have provision for carrying away the heat generated at the contact surfaces.
- The projecting parts of the clutch should be covered by guard.

4.1Parts of single plate friction clutch

A single plate clutch assembly for transmission of power consists of

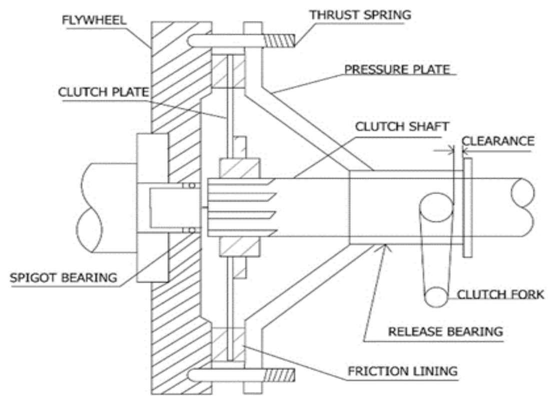

Figure 3 - Parts of single plate clutch[7]

1. Flywheel

The fly Wheel is an integral part of the engine, which also use as a part of the clutch. It is a driving member and connects to the pressure plate of the clutch shaft is houses with bearings in a flywheel. The flywheel rotates as the engine crankshaft rotates.

2. Pilot Bearing

The pilot bearing or bushing press into the end of the crankshaft to support the end of the transmission input shaft. The pilot bearing prevents the transmission shaft and clutch disc from wobbling up and down when the clutch releases. It also assists the input shaft center of the disc on the flywheel.

3. Clutch plate or Disc plate

It is the driven member of the single-plate clutch and line with friction material on both surfaces. It has a central hub with internal splines to limit the axial travel along the splined gearbox driving shaft.

This helps to provide damping actions against torsional vibrations or variations of the driving torque between engine and transmission. A clutch disc is a plate between flywheel and friction or pressure plate. It has a series of facings inverters on each side to enlarge the friction. These clutch facings are made of asbestos material. They are highly worn and heat resistant.

4. Pressure plate

The pressure plate is made of special cast iron. It is the heaviest part of the clutch assembly. The main function of the pressure plate is to establish even contact with the driven plate facing through which the pressure springs can exert a sufficient force to transmit the full torque of the engine.

The pressure plate presses the clutch plate on to the flywheel from its machined surface. Between the pressure plate and clutch cover assembly, pressure springs are fitted. The pressure will be withdrawn from the flywheel whenever release levers are depressed by the toggle or release levers are pivoted accordingly.

5. Clutch cover

The clutch cover assembly bolts to the flywheel. It consists of a pressure plate, release lever mechanism, clutch cover, and pressure springs. Generally, the clutch plate revolves with the flywheel. However, when the clutch has disengaged, the flywheel, as well as the pressure plates, are free to rotate independently from the driven plate and driving shaft.

6. Release levers

These pivots on pins to the clutch cover, their outer ends locate and positions on pressure plate legs, and the inner ends are projecting towards the clutch shaft. A careful and accurate adjustment of the release mechanism is one of the most important factors governing the performance of a clutch assembly.

7. Clutch shaft

It is a component of the gearbox. Since it is a splined shaft to the hub of the clutch plate, which is sliding on it. One end of the clutch shaft attaches to the crankshaft or flywheel and the other end connects to the gearbox or forms a part of the gearbox.

4.2Working of clutch

In the Clutch the three parts needs. These are the engine flywheel, a friction disc or a clutch plate and a pressure plate.

- Some springs give axial force to stay the clutch in the engaged position. When the engine is running and therefore the flywheel is rotating, the pressure plate also rotates because the pressure plate attaches to the flywheel. The friction disc is located between the flywheel and the pressure plate.
- When the driving force has pushed down the clutch is released. This action forces the pressure plate to move away from the friction disc against

the force of pressure springs. With this movement of the pressure plate, the friction plate is released, and therefore the clutch disengaged.

- When your foot is off the pedal, the springs push the pressure plate against the clutch disc, which successively presses against the flywheel. This locks up the engine to the transmission input shaft, causing them to spin at the same speed.
- The quantity of force the clutch can hold depends on the friction between the clutch plate and the flywheel, and in this way, much force the spring puts on the pressure plate.
- When the clutch presses, the piston pushes on the release fork, which presses the throw-out bearing against the center of the diaphragm spring. As the middle of the diaphragm spring pushes in, a series of pins near the outside surface of the spring causes the spring to pull the pressure plate away from the clutch plate. This releases the clutch from the spinning engine.[8]

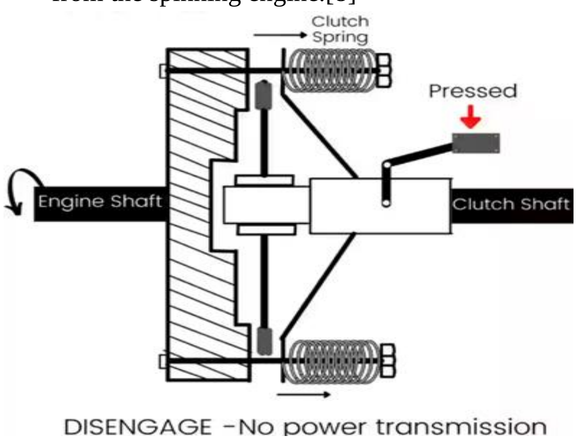

Figure 4 - Working of clutch [9]

Properties of some of commonly used materials for lining of friction surfaces are listed in Table 1

Materials	Tensile yield strength [MPa]	Poisson ratio [V]	Modulus of elasticity [GPa]	Density [Kg/m^3]
Asbestos	800	0.28	165	2800
Sintered metal	140	0.24	115	6400
Cermet	1039	0.23	380	5000
Ceramic	1138	0.22	325	2130
Kevlar	3240	0.36	71	1470

Table 1: Properties of different materials [10]

4.3 SYSTEM SURVEY

Structural analysis comprises the set of physical laws and mathematics required to study and predicts the behavior of structures. The subjects of structural analysis are engineering artifacts whose integrity is judged largely based upon their ability to withstand loads; they commonly include buildings, bridges, aircraft, and ships. Structural analysis incorporates the fields of mechanics and dynamics as well as the many failure theories. From a theoretical perspective the primary goal of structural analysis is the computation of deformations, internal forces, and stresses. In practice, structural analysis can be viewed more abstractly as a method to drive the engineering design process or prove the soundness of a design without a dependence on directly testing it.

It consists of linear and non-linear models. Linear models use simple parameters and assume that the material is not plastically deformed. Non-linear models consist of stressing the material past its elastic capabilities. The stresses in the material then vary with the amount of deformation. [11]

4.4PROBLEMS FACED WHILE PLANNING OF PROJECT

1. As we are making project on Design and analysis of single plate friction clutch, first of all the problem was not having proper knowledge about the clutch lining materials.
2. Second most important problem was getting dimensions of the single clutch plate and designing it perfectly.
3. The problem was learning about how to calculate the theoretical calculations for FEA analysis of clutch plate.
4. In order to work as a team in this situation(covid-19) was the major task.

5.DESIGN DETAILS

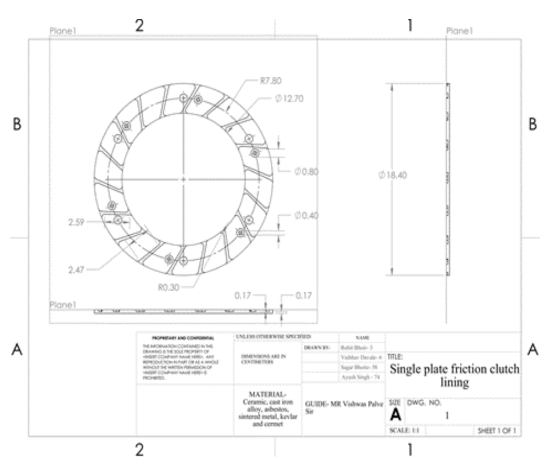

Figure 5 – Design of clutch plate lining

5.1CONSTRUCTION

The assembly of single plate clutch consists of 4 parts

- Brown color is clutch plate friction lining (2 number one at front and one at back).
- The centre most plate plate is the link that joins the two friction plates and the whole spring assembly.
- The grey part is the front disc that inbuilts the springs in it and also supports the assembly to move forward and backward according to input given (2 number one at front and one at back).

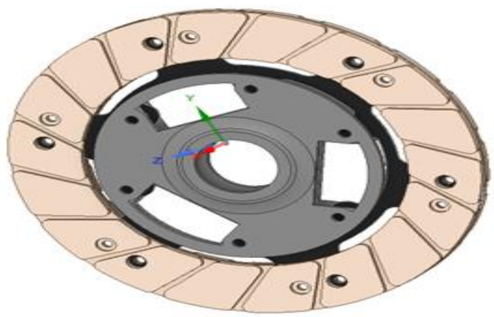

Figure 6 – Assembly of clutch plate made in Solid works

5.2 Steps followed while performing analysis

1. Modelling

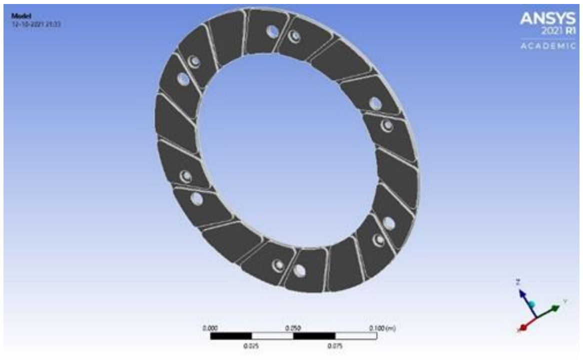

Figure 7 – Modelling of clutch plate friction lining

2.Meshing

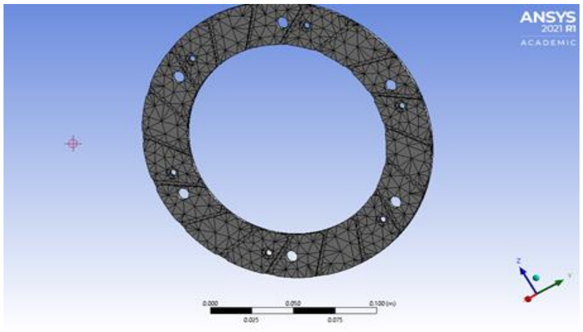

Figure 8 – Meshing of clutch plate friction lining

3.Applying pressure

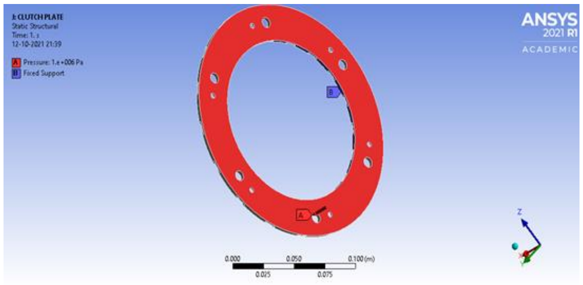

Figure 9 – Applying pressure on clutch plate friction lining

4.Applying support

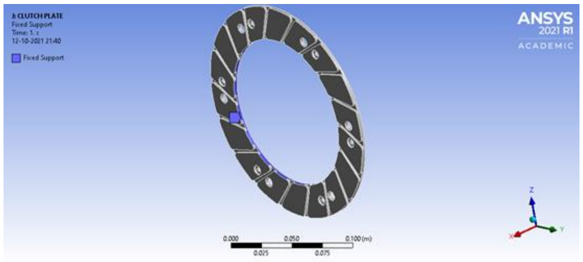

Figure 10 – Applying support on clutch plate friction lining

5.3TESTING AND ANALYSIS

Material 1- Asbestos

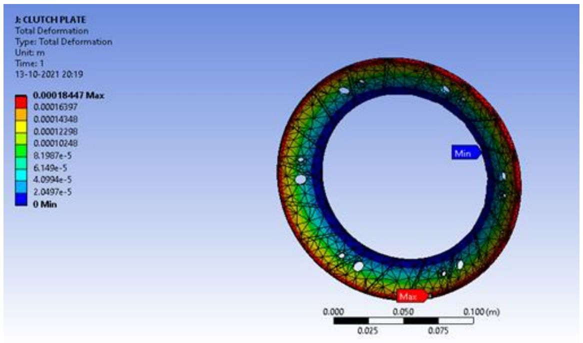

Figure 11 – Total Deformation 1.8447e-004 m = 0.018447 cm

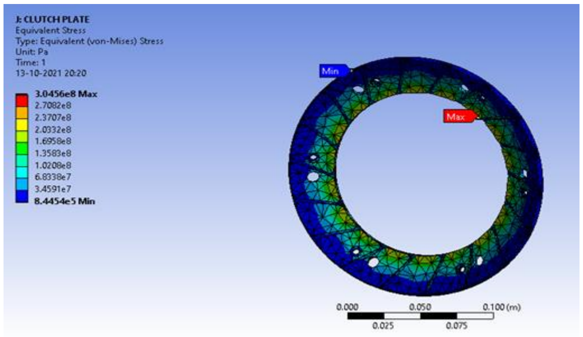

Figure 12 – Equivalent Stress 3.0456e+008 Pa = 304.56MPa

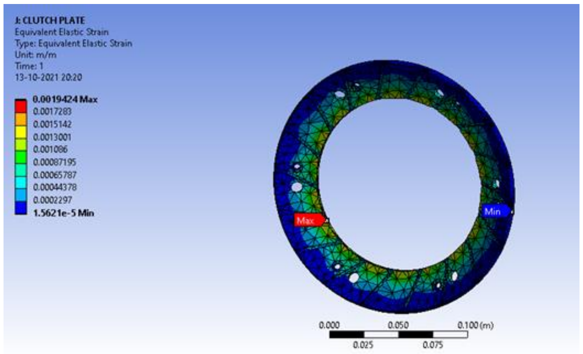

Figure 13 – Equivalent Strain 1.9424e-003 m/m

Material 2- Sintered metal

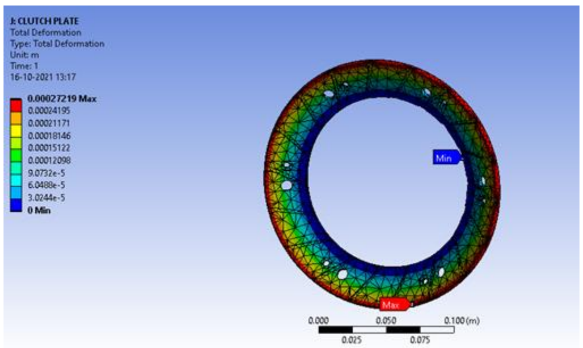

Figure 14 – Total Deformation 2.7219e-004 = 0.027219 cm

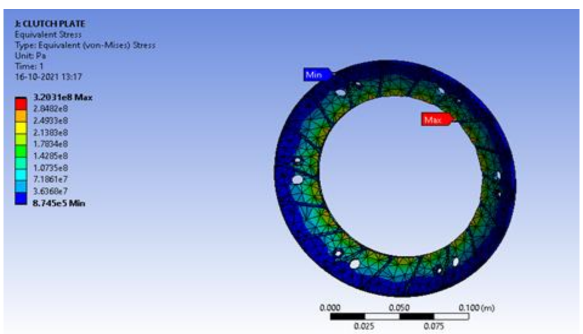

Figure 15 – Equivalent Stress 3.2031e+008 Pa = 320.31 MPa

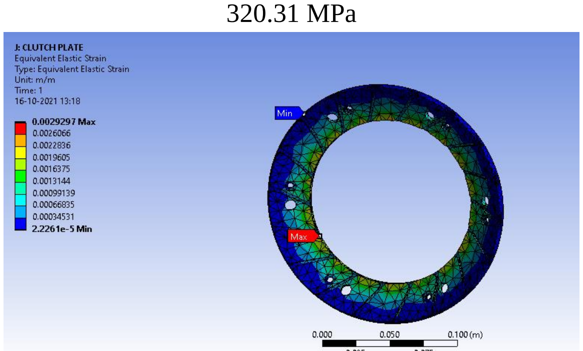

Figure 16 – Equivalent Strain 2.9297e-003 m/m

Material 3- Cermet

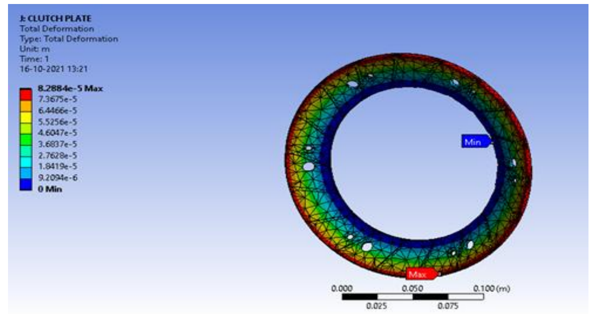

Figure 17 – Total Deformation 8.2884e-005 m = 0.0082884 cm

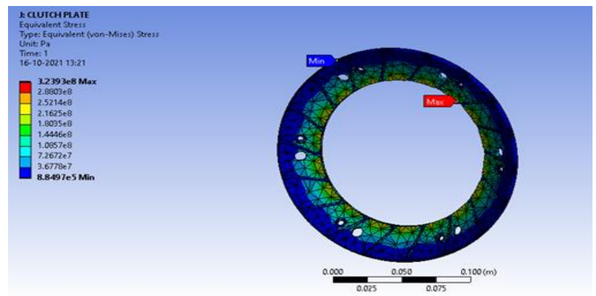

Figure 18 – Equivalent Stress 3.2393e+008 Pa = 323.93 MPa

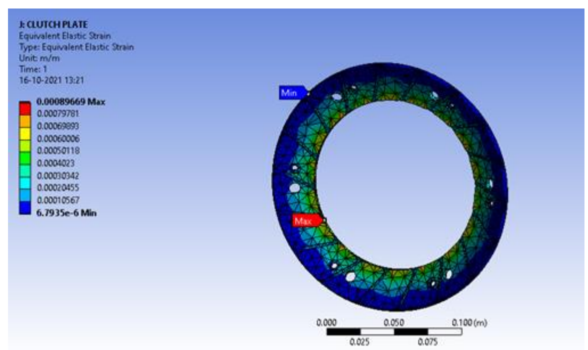

Figure 19 – Equivalent Strain 8.9669e-004 m/m

Material 4- Ceramic

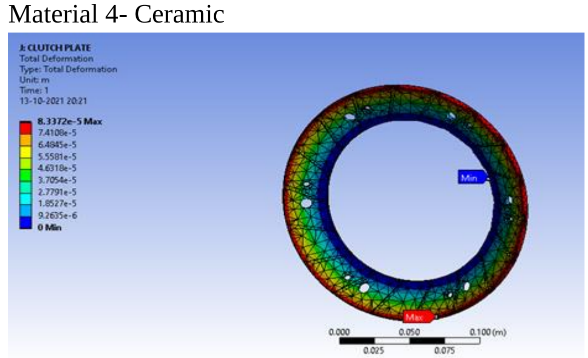

Figure 20 – Total Deformation 8.3372e-005 m = 0.0083372 cm

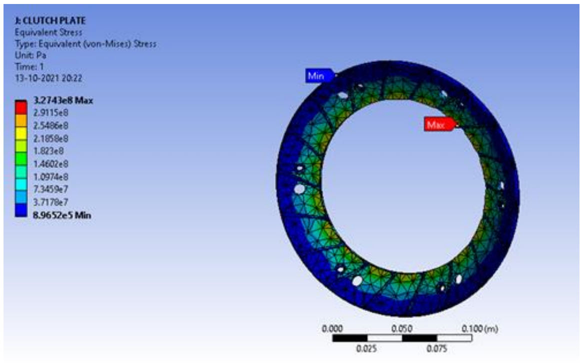

Figure 21 – Equivalent Stress 3.2743e+008 Pa = 327.43 MPa

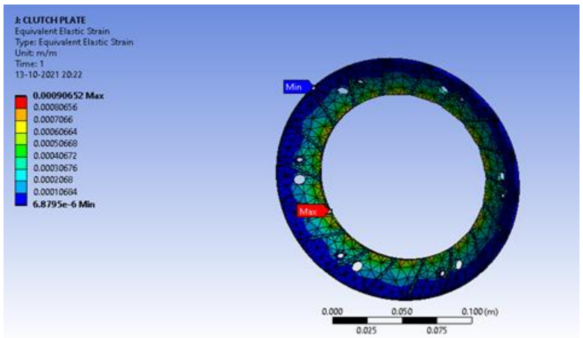

Figure 22 – Equivalent Strain 9.0652e-004 m/m

Material 5- Kevlar

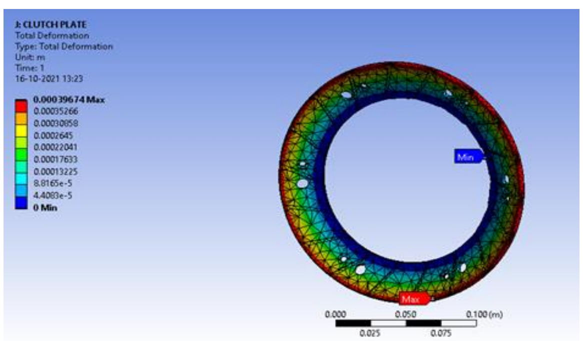

Figure 23 – Total Deformation 3.9674e-004 m = 0.039674 cm

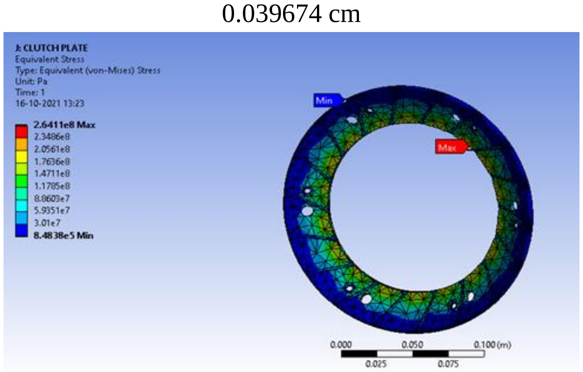

Figure 24 – Equivalent Stress 2.6411e+008 Pa = 264.11 MPa

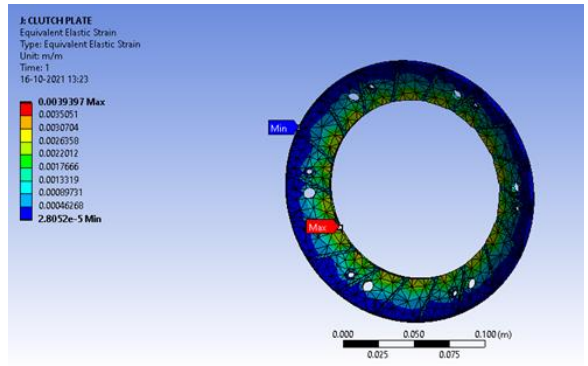

Figure 25 – Equivalent Strain 3.9397e-003 m/m

6.RESULT

Sr. No	Materials	Total Deformation [m]	Equivalent Stress [Pa]	Equivalent Strain (m/m)
1	Asbestos	1.8447e-004	3.0456e+008	1.9424e-003
2	Sintered metal	2.7219e-004	3.2031e+008	2.9297e-003
3	Cermet	8.2884e-005	3.2393e+008	8.9669e-004
4	Ceramic	8.3372e-005	3.2743e+008	9.0652e-004
5	Kevlar	3.9674e-004	2.6411e+008	3.9397e-003

Table 2 – Result obtained after performing analysis in ansys

6.1APPLICATIONS

- Single plate clutches are used in Buses, Trucks, and cars, etc. (Ashok Leyland, Flat – 1100, Truck)
- Single plate clutches used where large radial space is available.
- As sufficient surface area is available for the heat dissipation in Single plate clutches, no cooling oil is required. Therefore, single plate clutches are dry type. [12]

7.CONCLUSION

In this work, clutch plate of an automotive clutch assembly has been designed using different materials and simulated using ANSYS software for comparison. Among those different lining materials cermet friction material was selected as the best lining material as compared to the above selected 5 materials. Effect of same pressure intensity of 1 MPa for different materials was observed, clutch wear can be minimized by selecting suitable material. A good contact pressure also reduces wear during slippage time. This data helps the researchers to select proper material to reduce wear and increase life of clutch.

8.ACKNOWLEDGEMENT

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