DESIGN AND STRUCTURAL ANALYSIS OF CONVENTIONAL CLUTCH AND FLYWHEEL ASSEMBLY

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ABSTRACT

In an automobile the clutch assembly acts as a power transmission system or linkage which helps in transferring power from the engine shaft to the drive train of the gearbox. The gearbox helps in controlling the vehicle speed, whereas the input power to the gearbox assembly is provided by means of continuous engagement and disengagement of the clutch assembly with the engine flywheel. Hence, the clutch assembly is subjected to frequent wear and also the conventional assembly does not transmit full torque to the gearbox. Thus by proposing a design involving a docking mechanism the maximum torque can be transmitted which might also help in reduced wear and tear thereby extending the life time of components.

Keywords: Synchromesh Gear Box, Power Transmission System, Conventional Clutch etc

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1. INTRODUCTION

1.1 CLUTCH ASSEMBLY

A clutch is a mechanical device that engages and disengages the power transmission, especially from driving shaft to driven shaft.

Clutches are used whenever the transmission of power or motion must be controlled either in amount or over time (e.g., electric screwdrivers limit how much torque is transmitted through use of a clutch; clutches control whether automobiles transmit engine power to the wheels).

In the simplest application, clutches connect and disconnect two rotating shafts (drive shafts or line shafts). In these devices, one shaft is typically attached to an engine or other power unit (the driving member) while the other shaft (the driven member) provides output power for work.

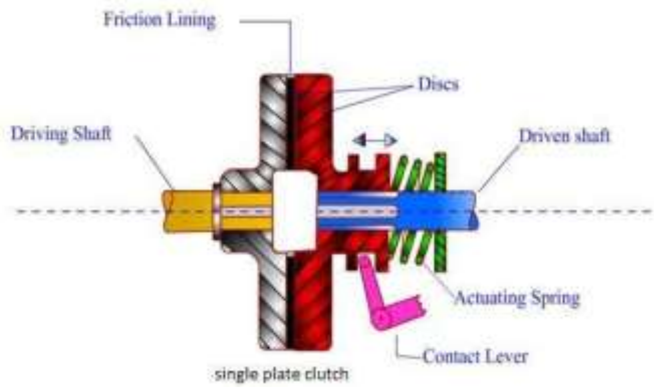

Fig- 1: Single plate clutch

1.2 COMPONENTS OF CLUTCH ASSEMBLY

The clutch mechanism works based on the various linkage actions performed by the components of the clutch plate assembly (or) clutch kit. The various components of a clutch assembly are studied as follows.

The various components of a clutch assembly are:

- Clutch plate
- Pressure plate
- Flywheel
- Torsion and damping springs
- Clutch housing
- Release lever and pedal linkages
- Clutch shaft, etc.

1.3 FUNCITONS OF A CLUTCH ASSEMBLY

- To transmit the engine torque to the drive wheels through a gearbox unit.
- Helps to connect and disconnect the engine with the gearbox as desired by the driver.
- To control the speed of the vehicle.
- Helps to enable smoother transmission while shifting of gears, etc.

1.4 FLYWHEEL

The flywheel acts as a member which transmits the generated power from the engine in the form of torque to the clutch assembly. The flywheel is mounted on a shaft which lies on the same axial line of the clutch shaft. The flywheel surface facing the gearbox is used as a friction surface for the clutch driven plate, and the cultch cover is bolted on that surface and rotate with it. Towards the hub it has a spigot bearing which allows the difference in speeds between the engine shaft and the flywheel.

2. DESIGN CONSIDERATIONS:

In order to design the clutch components various data related to the clutch assembly should be known. The data obtained helps in the design and modelling of the component. The various details such as clutch plate dimensions, clutch material, average clutch life, etc. are represented in the table below

2.1 CLUTCH SPECIFICATIONS:

Table- 1: Clutch specifications

1.	Clutch type	Single plate dry clutch
2.	Clutch plate diameter	353 mm (14" standard)
3.	Clutch material	Ceramic-Alloy 303, (300 series) with 10% nickel, 18% chromium and some amount of asbestos
4.	Average clutch life (hrs)	500 hours
5.	Average clutch life (kms)	30,000 to 35,000 kilometers (depends on the drivers usage)
6.	Direction of flywheel rotation	Anticlockwise
7.	Cubic capacity	5760 cc
8.	Type of gearbox	Synchromesh gearbox
9.	No. of gears	5

2.2 DESIGN OF CLUTCH PLATE

Fig- 2: Existing model of clutch plate

The above 3D part shows the existing model of a clutch plate. It has friction pads on its surface to enhance the friction contact during its engagement with the flywheel.

2.3 DESIGN OF FLYWHEEL

The flywheel from the engine transmits the power in the form of rotary motion.

Fig- 3: 3D model of Flywheel

3. ANALYSIS OF CONVENTIONAL CLUTCH MODEL

In order to identify the various stresses acting on the existing model, the process of analysis is done on the existing clutch model. The obtained results of this model is analysed and compared with the proposed design to access the various stresses acting on the new design.

3.1 ANALYSIS OF CLUTCH PLATE:

The designed components are meshed initially in order to perform analysis operation. The mesh size determines the number of elements and nodes formed.

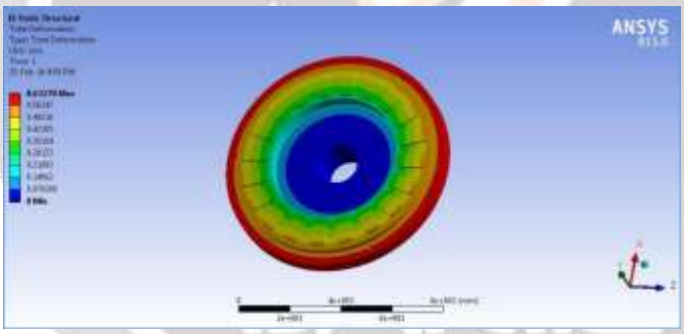

Fig- 4: Total deformations in conventional clutch

The total deformation indicates the sum of all deformation which is caused due to the various forces acting among the various axes of the component. This shows that the maximum deformation occurs towards the outer edge as a result of timely wear.

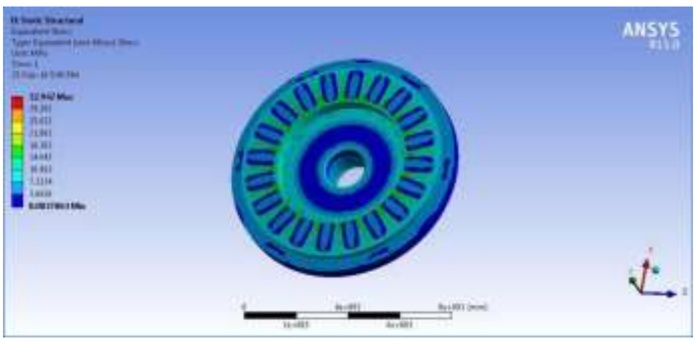

Fig- 5: Equivalent stresses acting on the clutch plate

The above figure indicates the effect on the clutch plate due to equivalent stresses acting on the clutch plate. It shows that the region in between the outer edge and the inner edge is subjected to more equivalent stresses and is subjected to more wear when compared to other regions.

Since the clutch plate slides towards and away from the flywheel along the axis of the shaft, the directional deformation is considered along the axis parallel to the axis of the shaft. This shows that the deformation takes place at maximum rate at the hub region of the clutch.

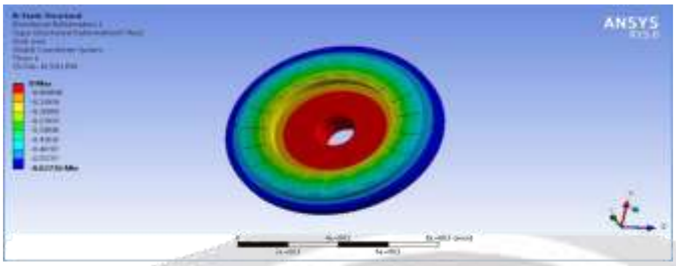

Fig- 6: Directional deformations on the conventional clutch

It shows that hub connected to the shaft tends to deform, since various forces targeted towards the region during the operating conditions.

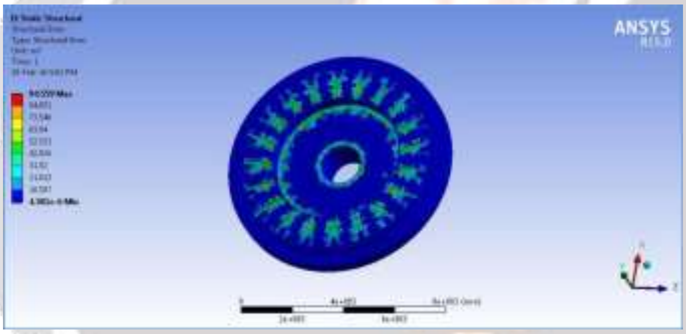

Fig- 7: Structural error in conventional clutch

This figure illustrates where the error in structure takes place due to continuous loads. It shows that it error arises from the inner central region and is radiated towards the outer side. The deformation and error is maximum towards the central region since the clutch is subjected to rotational moment on its axis.

3.2 ANALYSIS OF FLYWHEEL

Material	: Mild steel
Young’s modulus	: 190000 MPa
Poisson’s ratio	: 0.3
Torque applied	: 578.59 x 10^3 N-mm
Force	: 7210.92 N
No. of nodes	: 36742
No. of elements	: 21789

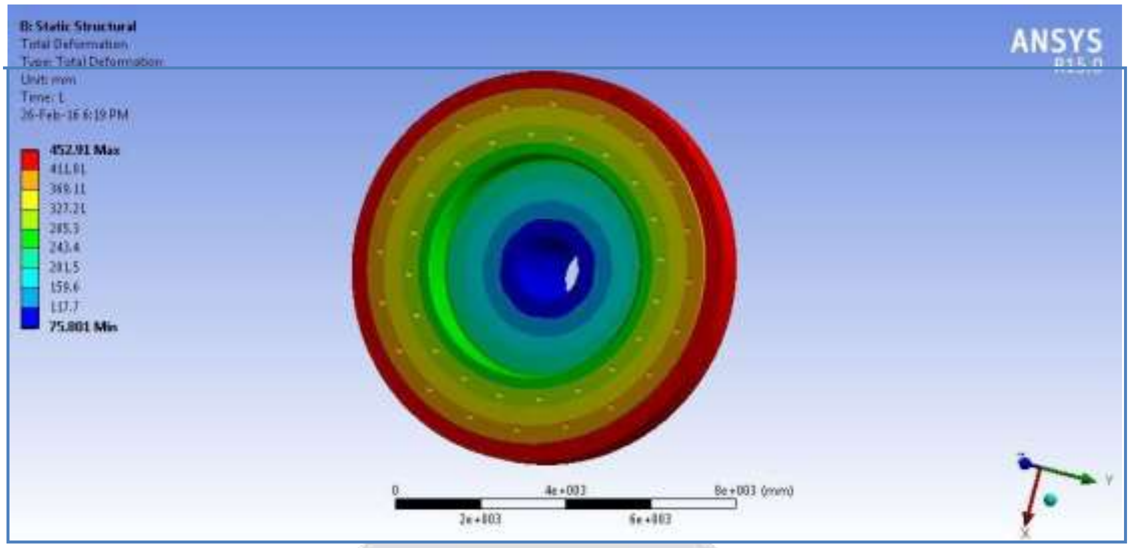

Fig- 8: Total deformations in flywheel

Similar to the clutch plate, the total deformation usually occurs towards the external region of the flywheel. This total deformation occurs due to the timely wear of the component under continuous running of the component.

Also the Equivalent stress (von-Mises) shows that the region towards the hub and its surrounding region are subjected to more wear than usual when compared to the other regions.

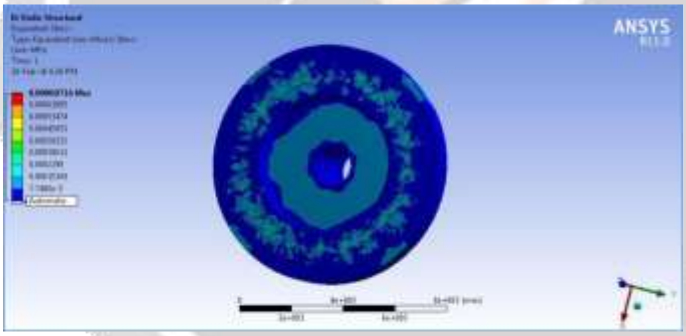

Fig- 9: Equivalent stresses on flywheel

The above figure shows the region where more stress acts thereby causing deformation. It is visible that the inner region towards the hub is subjected to more stresses.

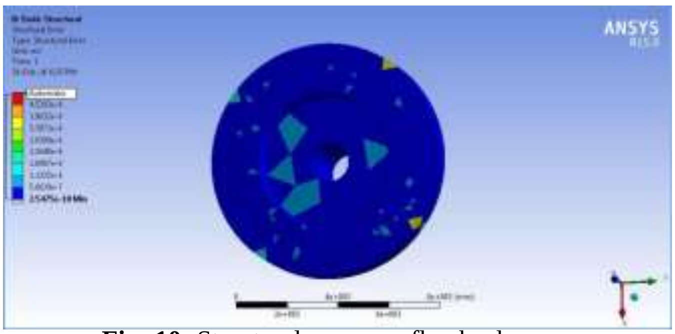

Fig- 10: Structural errors on flywheel

Similar to the results of the equivalent stresses acting on the flywheel, the structural errors indicates the regions where the structure of the flywheel gets affected due to continuous force acting upon it.

The analysis of the complete assembly is also carried out in order to analyse and check the various stress and deformation acting on the components.

3.3 ANALYSIS OF EXISTING CLUTCH ASSEMBLY

Material	: Mild steel
Young's modulus	: 190000 MPa
Poisson's ratio	: 0.3
Torque applied	: 578.59 x 10^3 N-mm
Force	: 7210.92 N

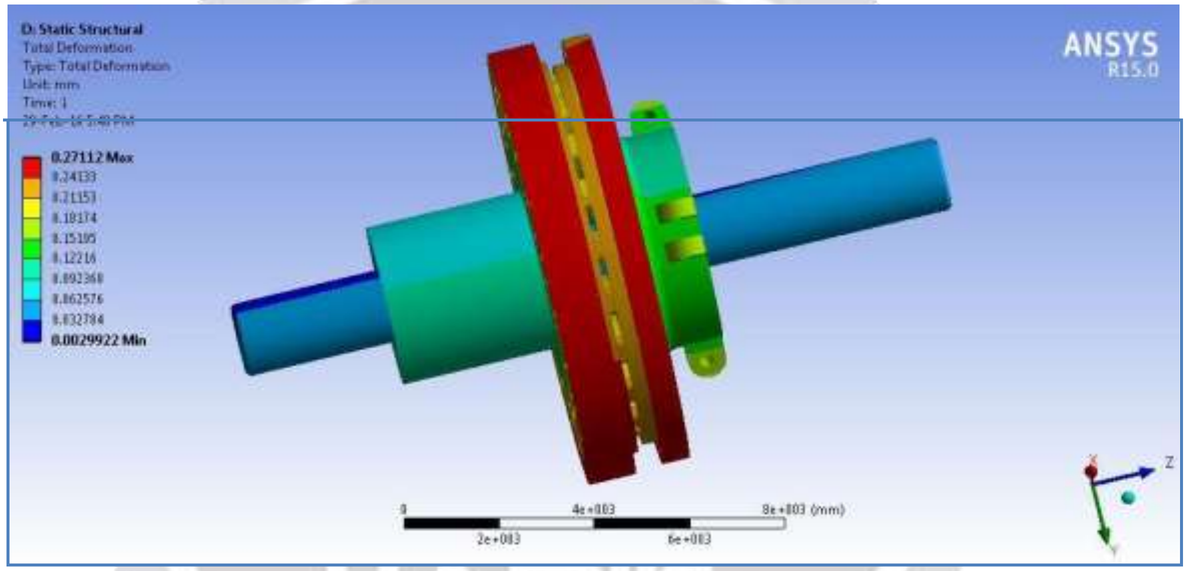

Fig- 11: Total deformations on existing assembly

The analysis carried out on the assembly shows that deformation takes place on the outer edge after certain number of cycles. The actual deformation and the stress region is identifies by performing von-Mises stress analysis and structural error analysis.

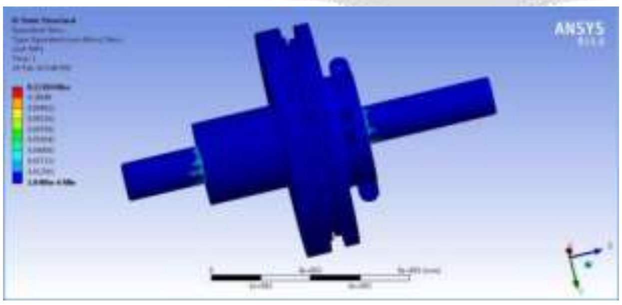

Fig- 12: Equivalent stress analyses on existing assembly

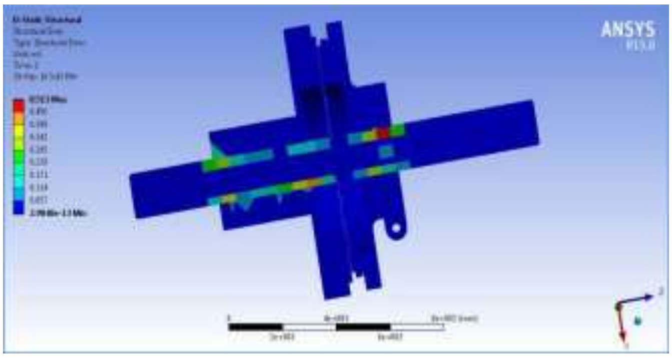

Fig- 13: Structural errors in existing assembly

From equivalent stress analysis and structural error analysis it is found that the maximum error, stress and deformation towards the central region. This concludes that the region towards the centre is prone to more damage than the contact region of the clutch. Since the contact region is subjected to forces only during the process of engagement and disengagement, whereas the components rotating on the shaft experiences more stresses acting on it.

3.4 ANALYSIS OF PROPOSED CLUTCH ASSEMBLY

Material	: Mild steel
Young's modulus	: 190000 MPa
Poisson's ratio	: 0.3
Torque applied	: 578.59 x 10^3 N-mm
Force	: 7210.92 N
No. of nodes	: 130062
No. of elements	: 71849

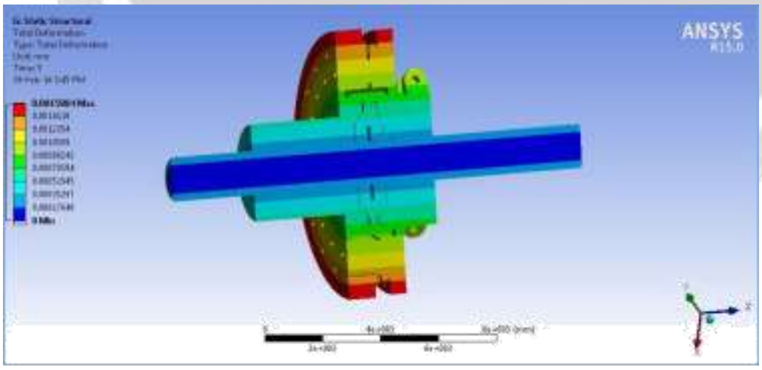

Fig- 14: Total deformations on proposed assembly model

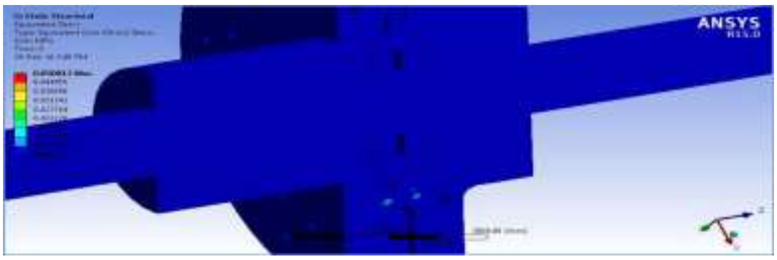

Fig- 15: von-Mises stresses acting on proposed assembly

The analysis of proposed model shows that the von-Mises stresses acting on it is low when compared to the existing clutch assembly. It is seen that the proposed design is subjected to less wear and the existing design has the ability to deform and wear out quickly than the proposed design. Also the proposed model shows that it has more resistance to high stresses acting upon it and has the ability to transmit higher torque.

4. RESULTS AND DISCUSSIONS

4.1 COMPARISON OF PROPOSED ASSEMBLY WITH EXISTING ASSEMBLY

From the analysis of the components various results were obtained for both the existing assembly and the designed setup. The various data obtained through analysis process is tabulated below:

Table- 1: Comparison of conventional clutch with designed clutch.

S.No:	Properties	Conventional clutch	Designed clutch
1.	Total Deformation (mm)	0.27112	0.07906
2.	Von-mises stress (MPa)	0.3108	0.12204
3.	Structural error (mJ)	0.513	0.10035

From the obtained results graph is drawn to illustrate and differentiate the various factors that affect the conventional clutch model with the designed clutch assembly.

The graph below shows the variation in the total deformation between the conventional and designed assembly model of the clutch.

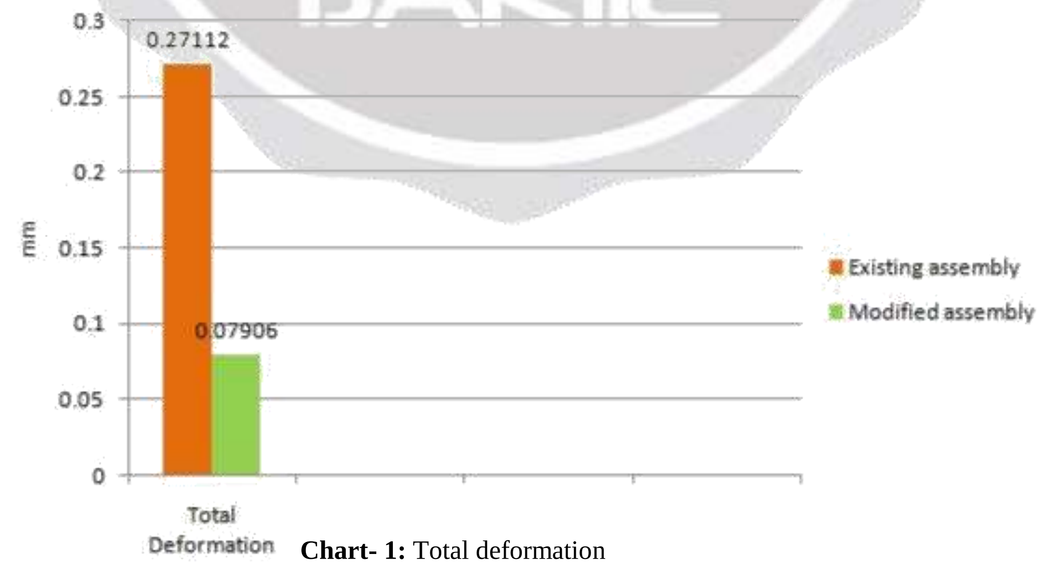

Chart- 1: Total deformation

This chart shows that the total deformation taking place in the designed assembly is much less than the deformation that occurs in the conventional assembly. When comparing both it seems that the conventional assembly undergoes deformation earlier when compared with the designed clutch assembly.

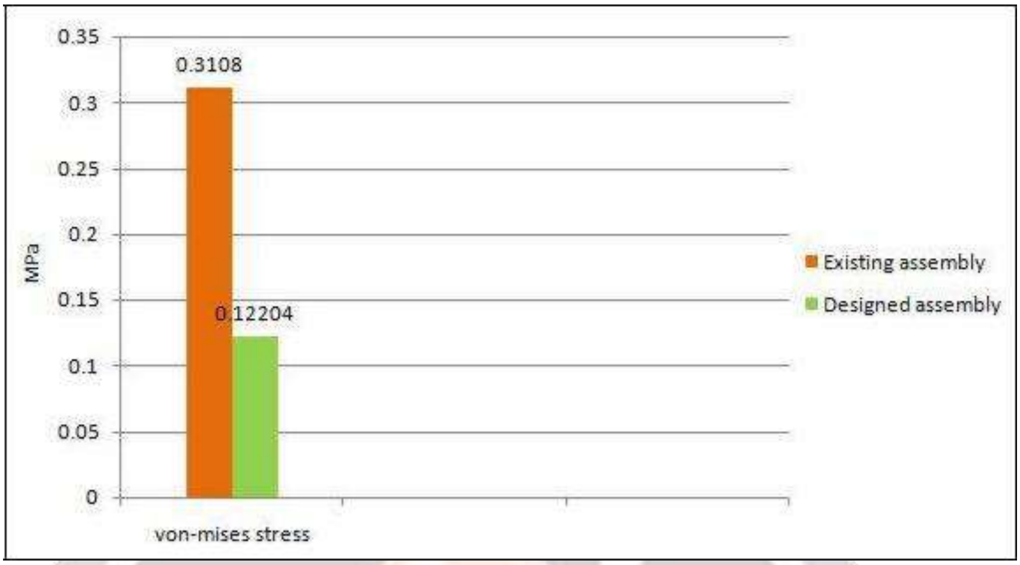

Chart- 2: von-misses stress

The von-mises analysis shows the stresses acting on the components. It helps to determine the various forces acting on it. The stresses acting on the conventional assembly is more than the designed assembly. Hence, the larger stress acting on the component for a given period of time results in premature wear. The proposed design eliminates this problem.

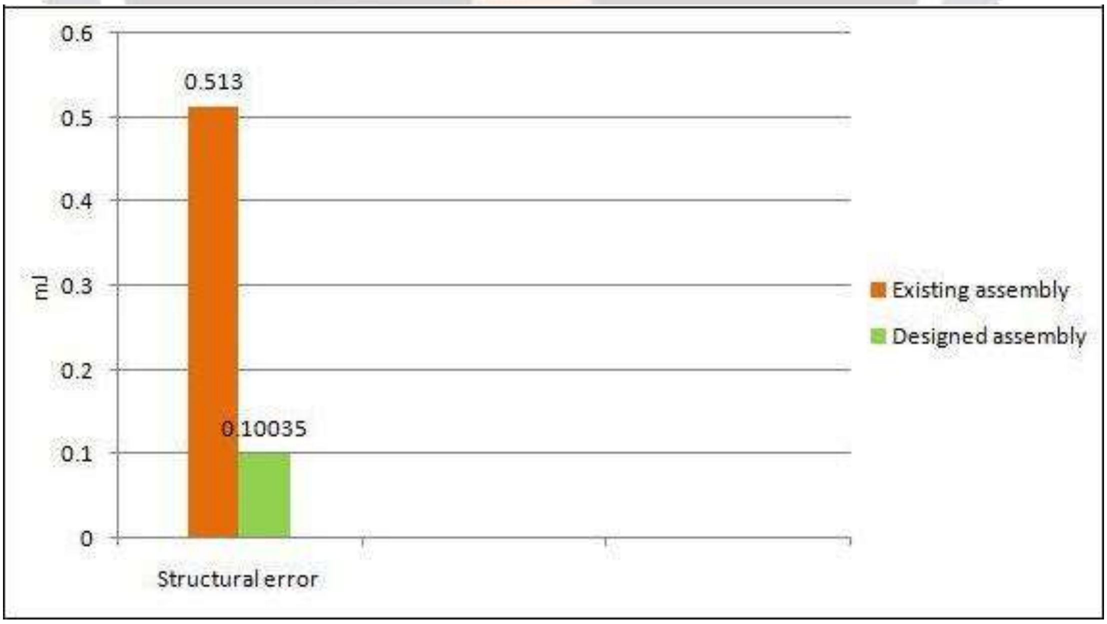

Chart- 3: Structural error

Structural error indicates where an error is likely to occur in the structure of the component. It is seen that for a clutch assembly the structural error occurs towards the hub region. With the designed assembly the structural error occurring in that region is very much lower.

The various results obtained from the analysis process and from the graphical representation various factors can be stated as follows:

- It is seen that the proposed assembly can transmit higher torque when compared with the existing assembly.
- The proposed model can withstand high amount of torsion forces acting on it, whereas the same amount of forces acting on the existing model may result in reduced life time.
- The existing assembly do not deliver smooth torque transmission since the flywheel and clutch plate rotating at different speeds comes in direct contact while engaging.
- The proposed assembly delivers smoother torque since the clutch and the flywheel rotating at different speeds are synchronised by means of a synchroniser which reduces the stresses acting on the friction surfaces.
- Since the designed component takes place at the region where initial stresses occur, it takes up the wear and helps in prolonged life of the clutch plate.
- From the comparisons and discussions, it is seen that the proposed component reduces the maintenance costs when compared to the maintenance of the existing design. Also the proposed design prolongs the life of the assembly.

5. CONCLUSION

From this project it is found that the proposed design improves the torque transmission from the engine to the drive train. The components are designed according to the design space available in the existing assembly and the use of synchroniser enables smoother engagement of the components. The analysis of designed component proves that the design is safe and the various stresses acting on it lies within the limit so that it reduces the wear rate and prolongs the life time of the component. The proposed design may be implemented into production so that more reliable clutch assembly can be employed in trucks.

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