

A Review on Clutch

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Abstract- The aim of this review paper is to represent a study on the clutch. Clutch system is among the main systems inside a vehicle. 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. At high sliding velocity, excessive frictional heat is generated which lead to high temperature rise at the clutch disc surface, and this causes thermo-mechanical problems such as thermal deformations and thermo-elastic instability which can lead to thermal cracking, wear and other mode of failure of the clutch disc component.

Keywords- Clutch, friction material, friction plate, analysis, clutch plate, Ansys

I. INTRODUCTION

A clutch is a mechanical device for quickly and easily connecting or disconnecting a pair of rotating coaxial shafts. It is usually placed between the driving motor and the input shaft to a machine, permitting the engine to be started in an unloaded state. Single plate, dry clutch is among the popular type of clutches in use. A clutch is a mechanism designed to disconnect and reconnect driving and driven members. It is a device, which enables one rotary drive shaft to be coupled to another shaft, either when both the shafts are stationary or when there is relative motion between them. The need for the clutch seems mainly from the characteristics of the turning-effort developed by the engine over its lower speed range. When idling, the engine develops insufficient torque for the transmission to be positively engaged. To obtain a smooth engagement, the clutch has to be progressively engaged to take up the drive until the torque transmitted from the engine equals that required to propel the vehicle. Also the clutch disconnects the engine from the transmission to change the gear. The clutch, thus, takes up the drive smoothly and also disengages the drive whenever necessary. Automotive clutches are located between the engine and the transmission. It provides mechanical coupling between the engine and

transmission input shaft. Manual transmission cars need a clutch to enable engaging and disengaging the transmission. The clutch engages the transmission gradually by allowing a certain amount of slippage between the flywheel and the transmission input shaft. Clutch basically consists of six major parts: flywheel, clutch disc, pressure plate, diaphragm spring, clutch cover and the linkage necessary to operate the clutch as shown in Figure 1. [4]

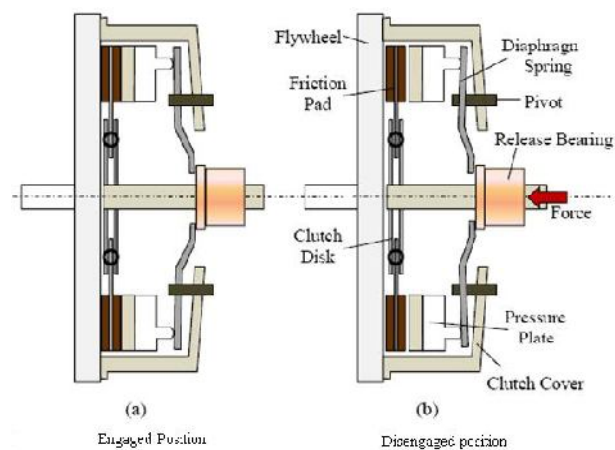


Figure 1. Single plate diaphragm clutch system. [4]

Desirable properties for friction materials for clutches:

- The two materials in contact must have a high Coefficient of friction.
- The materials in contact must resist wear effects, such as scoring, galling, and ablation.
- The friction value should be constant over a range of temperatures and pressures. The materials should be resistant to the environment (moisture, dust, pressure)
- The materials should possess good thermal properties, high heat capacity, good thermal conductivity, withstand high temperatures. Able to withstand high contact pressures
- Good shear strength to transferred friction forces to structure. [6]

- 1) N.V.Narasimharao, the main objective of this work is to design and analyze the clutch plate on the basis of crack propagation and its growth in a clutch. Crack propagation of clutch plate is analyzed for different materials such as Aluminium alloy 6061, aluminium alloy 7475, Composite material S2 Glass and Kevlar. Stress intensity

factor, crack extension force, crack opening displacement are determined by theoretical calculations. Finite element analysis software Ansys is used for static and Dynamic analysis. The analysis is done on the clutch before crack and propagated crack after load steps. The results obtained from this analysis were, the stress values are more for composite material but when crack starts to propagate stress value increases more than that of no crack condition. So, the composite materials fail faster, once the crack propagates. Conclusion is that, when crack propagates in the composite materials, they fail at faster rate reducing their life than that of aluminium alloys. So, care should be taken for composite materials not to get cracked.

- 2) B. Nivas, the objective of this work is to reduce the cost of clutch plate without affecting function, performance and life of clutch plate. Clutch plates are usually manufactured from cast iron and high carbon steel. Properties of CI have high compressive strength, low tensile strength and no ductility which can be easily machined. Because of this reason, gray CI is used for clutch plate but its cost is high. Due to high cost of gray CI another material is used without affecting the life and effectiveness of the clutch plate. Substitution to gray CI, we use steel En –Gjs-400 -15steel having similar properties of gray CI. Then we analyze both the materials to obtain the stress in the materials with the help of Ansys software. We found that, maximum deformation in mm, vonmises stress in Mpa, the En –Gjs-400 -15steel is better for the production of the clutch plate than the gray cast iron [FG 300]. En 15 steel reduces the stress on the suort link is 167.911 Mpa, where as the yield stress of FG 300 is 181.033. so, the life of material should be high. Stress is reduced to 46.937 Mpa, where as stress on gray cast iron is 52.145 Mpa.
- 3) Anil Jadhav, depicts the solid modelling of multiplate clutch with PRO-E CAD package that is employed for varied automobile applications. The structural analysis of clutch plate is done over cork, copper and SA92 as friction lining materials. The analysis is carried out in ANSYS workbench to get the foremost appropriate material for clutch. From the analysed results, stress, strain and total deformation values were compared for all the three materials and the best one was taken out.
- 4) Mamta G. Pawar, in single plate clutch friction plate plays very important role in torque transmission system. So, the friction material property is very important in clutch. So, for designing of clutch disc one should know the wear rate of that material which are used in clutch disc and

common failure problem associated with clutch, again when some force is acting on clutch disc there must be some deformation due to temperature variation and stresses developed in clutch disc. That should be within permissible limit. Friction pads are manufactured by sintering blend of powders consisting of heat absorption material along with friction generating and lubricating materials. Particulate reinforcement gives the necessary wear resistant for the sintered matrix. Analysis of single plate clutch using sintered iron as a friction material. FEM using sintered iron as a friction material. We obtain the result, total deformation is found to be 0.293×10^{-4} mm & stress is found to be 6.237×10^{-3} Mpa. Result validation is done by using Ansys result for sintered material. The result obtained is total deformation is 5.308×10^{-5} mm and Von-misses stresses 0.0066447 Mpa. After designing of clutch disc, the analysis is done by varying the friction material and following conclusions are drawn. The stresses using Kevlar as a friction material and sintered iron is near about same. Torque transmission capacity of sintered iron friction material is 350 to 400 N which is more than Kevlar. Total deformation in Kevlar material is less than sintered iron friction material. Sintered iron can sustain higher temperature. By applying the maximum force i.e 220 N of the friction plate of single plate clutch, after analytical calculations and software analysis the following observations can be obtained.

SINTERED –IRON (FRICTION MATERIAL)		
Analytical Calculation		Software Analysis
Total Deformation	0.393×10^{-4} mm Or 3.93×10^{-5} mm	0.5308×10^{-4} mm or 5.308×10^{-5} mm
Stresses	0.6237×10^{-4} N/mm ² 6.237×10^{-5} Mpa	0.00664 Mpa

- 5) V Mani Kiran Tipirineni, this work explains the structural design of the clutch plate and find out the failure region by doing static analysis in ANSYS software. FEA is used to analyze the clutch driven plate. The results from the FEA are accurate and hence being used worldwide for design and research engineers. The driven plate used in Leyland Viking vehicle is analyzed in this work. The driven main plate failed normally during its operation due to cyclic loading. The driven plate under analysis is a fan type clutch. The shape of the clutch is like a fan. Crack is formed on the side of the clutch. Side plate consists of various slots in which damper springs are engaged. Damper springs are used to absorb the torque during the engagement of the clutch. The crack is formed between

these two windows. From the analysis result, the maximum value of the stress in a actual side plate is very near to the theoretical endurance limit. Due to which the crack is formed on the side plate. To increase the life of the side plate, some modifications are done on side plate to reduce the maximum stress. The thickness of the plate is increased and this modification gives maximum stress lesser than the maximum stress of the actual side plate. Factor of safety is increased to 1.23. Alternative modification of the side plate is done by increasing the fillet radius. The maximum stress obtained by this modification is lesser when compared to previous modification.. Factor of safety is increased to 1.52. In order to reduce the maximum stress further , both the above said modifications are combined. The maximum stress is reduced further. Factor of safety is increased to 1.7. This design has highest factor of safety than other modifications. This ultimately increases the life of the driven plate. This design is also tested practically in the lab and it is confirmed that the life of the driven plate is increased.

- 6) K. Tripathi, the friction clutch must be design for minimum axial force between the pressure plate & clutch plate. They suggested that for optimum design of friction disc the ratio of inner radius to outer radius should be kept 0.577. There basic design is based on minimum axial force between pressure plate & clutch plate.
- 7) Ganesh Raut, multi plate clutch is most widely used in racing cars and heavy duty vehicle where high torque transmission required and limited space is available. 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. In this work we 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. Structural analysis by varying the friction surfaces material and keeping base material aluminium same. The two materials used are SF-BU and L031. SF-BU is a high performance, high friction, non-metallic composite material containing a high percentage of aramid fibre. It is suitable for both dry and oil-immersed applications. It is not abrasive to the counter material, it will with stand high pressure. The wear rate is low even at high temperatures, is available in thicknesses from 0.6mm to 5mm. LO31 is a rigid moulded friction material, whose main characteristics are the low dynamic friction coefficient having the lowest friction. It is composed basically of resins as a link system with frictional modifier agents. This material has good mechanical properties. Structural analysis is done on the friction plates to verify the strength. By observing the analysis results, the maximum shear stress, Von-Mises stress and total deformation values for hybrid SF-BU are less than LO31 respective values. So, for multi plate clutches using as hybrid SF-BU friction material is advantageous than using LO31 as friction material.
- 8) Samir Safarni, after gear shift & during the clutch re-engagement the clutch disc allows the transmission of progressive torque through its Axial Stiffness. One of the most important components use in coupling & decoupling of motor & transmission during gear change. One of the most important components used in this process is clutch disc that allows a soft gradual re-engagement of torque transmission. This progressive re-engagement obtained by friction disc characteristics in the axial direction preserves the drivers comfort & avoid mechanical shock.
- 9) Abhijit Devaraj, the aim of this work was to design a single disk friction clutch plate made of Kevlar 29 and optimize the design, based on static analysis performed on the clutch using Ansys workbench software. This work sheds light upon how to optimize the design of the clutch plate, so as to deliver maximum performance and last longer. Kevlar 29 is highly durable material and is more resistant to hard use. Kevlar clutch plates can be used for street driven cars up to 500hp, for auto-x and heavy track use. The total deformation and Von mises stress concentration in the clutch were determined when the ambient temperature was maintained at 40°C. The factor of safety assumed in this theory is high which facilitates a safer design. The pressure plate is riveted to the clutch. Fixed constraints were applied to six rivets hole and pressure of 1 Mpa was applied to friction surface of the clutch plate. The experiment was repeated for different hub diameter and also different rivet hole size. The conclusions made were, that the maximum Von Mises stress was found in the rivet hole regions. Also minimum deformation was found in rivet hole regions which were constrained as fixed. It was observed that by increasing the hub diameter in the clutch plate within certain limits the maximum total deformation and the maximum Von Mises stress can be decreased. It was found that by increasing the rivet hole size (within certain limits) when the hub diameter was kept constant, the maximum total deformation and the maximum Von Mises stress can be decreased. Therefore a clutch plate design can be optimized by increasing the hub diameter or increasing the rivet hole diameter (within certain limits) in order for the clutch to deliver maximum performance and last longer.

- 10) B.Sreevani, the present used material for friction disc is Cast Iron and aluminium alloys. In this work analysis is performed using composite materials. The composite materials are considered due to their high strength to weight ratio. In this thesis composite material E Glass Epoxy and Aluminium Metal Matrix Composite are taken. A single plate clutch is designed and modelled using Creo 2.0 software. Static analysis and Dynamic analysis is done on the clutch to determine stresses and deformations using materials Grey Cast Iron, Aluminium alloy 7075, E Glass Epoxy and Aluminium Metal Matrix Composite. Static Analysis used to determine displacements, stresses, etc. under static loading conditions. Dynamic Analysis used to determine the response of a structure to arbitrarily time-varying loads. Analysis is done in Ansys. Theoretical calculations are also done to determine stresses. The advantage of using aluminium alloys is their light weight. The advantage of using composite material is their strength to weight ratio. By observing the static analysis results, the analysed stress values are less than the respective yield stress values of Aluminium alloy 7075, aluminium MMC and E – Glass epoxy. So using the materials is safe. By comparing the results between materials, E – Glass Epoxy is more advantageous than other materials due to its less weight and high strength. Theoretical calculations are also done to determine stresses for all the materials. By observing the results, the stress values are less than the respective allowable stress values for all materials. By observing the E Glass Epoxy results, the stress value is less. So it can be concluded that by analytical and theoretical results, E Glass Epoxy is better.
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II. CONCLUSION

In this paper a review of the research papers related to clutch are studied and after that it is concluded that there is much more scope of research work to do in this area. On this basis, my work is going to be on non asbestos liners and two conditions of liners will be studied namely full face lining and staggered lining.

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