Design Modelling & Analysis of Automotive Single Plate Friction Clutch

Lembhe Nagesh Somnath[1], Gangurde Rahul Satish[2]
[1] *Assistant Professor, Department of Mechanical Engineering, Sahyadri Valley College of Engineering & Technology, Rajuri, Tq. Junnar. Dist. Pune.Maharashtra, Pune*
[2] *Assistant Professor, Department of Mechanical Engineering, Sahyadri Valley College of Engineering & Technology, Rajuri, Tq. Junnar. Dist. Pune.Maharashtra, Pune*

***Abstract*- A clutch is a mechanism which is used to transfer rotary motion from one shaft to another shaft. When both shaft are coincident with each other. The friction clutches work on the fact that friction is cause when to rotating disc come into contact with each other. To avoid failure of a clutch, it is necessary to find the stresses and analyze vibration parameters of the clutch. This paper deals with study of designing a friction clutch assembly using Pro-e software and its structural analysis using FEA. Modal analysis is carried out to optimize the natural frequency of the single plate clutch to avoid being in resonance with the engine frequency range. The results show that natural frequencies of original model of clutch and natural frequencies of simplified model of clutch are in good agreement with each other.**

***Index Terms*- Friction clutch, Rotating disc, Natural Frequency, FEA.**

I. INTRODUCTION

Clutch is a mechanical component which is used in the transmission system of a vehicle to engage and disengage the transmission system from the engine. The clutch is mounted between the engine and gear box. In a vehicle, at running condition clutch is always in the engaged position. When the clutch pedal is pressed, the pressure plate moves back against the force of the springs and the clutch plate becomes free between the flywheel and the pressure plate.

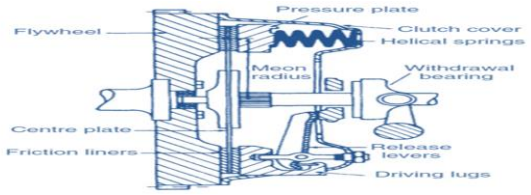

Fig 1. Single Plate Friction Clutch

The pressure plate is bolted to the flywheel through the clutch springs which are arranged radially inside the body. Clutch springs push the clutch plate towards the flywheel. When the clutch is engaged, the clutch plate is gripped between the pressure plate and the flywheel. Due to the friction linings on both sides of the clutch plate, the clutch plate is revolves with the flywheel.

Clutch shaft is connected to the gearbox. So, the engine power is transmitted to the driving wheels. When the clutch pedal is pressed by the truck driver, the clutch is said to be in disengaged position. And the pressure plate is move back due to spring force.

The clutch plate becomes free, remains the flywheel rotates as long the engine in running. " Control of the torque of the engine is depends on contact area of the clutch". If contact area of the clutch with the flywheel is increases then the torque is also increases. If contact area of the clutch decreases torque also decreases. Single plate clutches are mostly used in heavy vehicles like trucks, buses and etc.

The pressure plate pushes the clutch plate towards the flywheel by spring's pressure which is arranged radially inside the clutch body. The three levers are supported on pivots suspended from the case of the body. By the inward movement of a thrust bearing pressure plate moves away from the flywheel. When the clutch pedal is pressed the bearing which is mounted upon a forked shaft and moves forward. By moving the foot back from the clutch pedal, the thrust bearing moves back and allows the spring to extend which pushes the clutch plate backwards the flywheel. This engages the flywheel and the clutch plate which starts the motion of the driven shaft.

O.I. Abdullah et al (2013) studied optimization of shape and design parameters of the clutch disc using FEM tool. The numerical solution of computing the

stresses and vibration characteristics of rigid clutch disc is presented. For numerical solution ANSYS and Solid Works have been used. The results show that by adjusting the design parameters stresses and vibration characteristics can be controlled and suggested models improve the response of friction clutch. [1]

Animesh Agrawal et al (2014) explained Optimization of Multi plate friction clutch for maximum torque transmitting capacity using uniform wear theory. This theory is used to solve the optimized results for multi plate clutch. But in actual practice, due to tolerances design variable becomes probabilistic. This gives proper considerations at the time of design. [4]The objective function was calculated by variation in value of number of friction surface, in value of friction coefficient, in value of intensity of pressure. The result charts can be used for improve the clutch design parameters.

Ali Belhocine et al (2016) presented a numerical parametric study of mechanical behavior of dry contact slipping on disc pads interface. The determination and visualization of structural deformations due to contact of slipping between the disc and pads is presented. The variations of stresses in rotating disc and ring bodies are predicted by meshed models. Using the developed model, the influence of design parameters on result was examined using Finite Element Method. Influence of fine mesh, friction coefficient, young's modulus of pad material, speed of the disc on the computation results was studied. [2]

II MODELLING OF SINGLE PLATE FRICTION PLATE

The clutch assembly model has been created by Pro-E software. First of all pro-e is opened. Then by using 2d commands sketch is created. After that 3D model of clutch assembly created by using extrude and revolve commands.

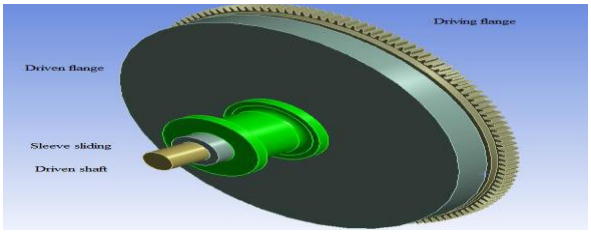

Fig 2. Model of single plate friction clutch

III MATERIAL SELECTION

The following materials are selected for finite element analysis.

1) Clutch base plate: Structural steel
2) Friction material: Kevlar aramide fiber 49
3) Pressure plate: Grey cast iron

Properties	Material 1 (Structural steel)	Material 2: Kevlar aramide fiber 49	Material 3 (Grey cast iron)
Density (kg/m3)	7850	1410	7200
Young's modulus (Mpa)	2*1011	1.2*1011	1.12*1011
Poisson's ratio	0.3	0.36	0.29
Bulk modulus (pa)	1.6667*1011	1.3333*1011	9.5328*1010

Table 1. Material Properties

IV FINITE ELEMENT ANALYSIS

The Finite Element Analysis (FEA) is the simulation of any given physical phenomenon using the numerical technique called Finite Element Method (FEM). FEM is a numerical method which is used to solving problem of engineering and mathematical physics. Generally engineers use it to reduce the number of physical prototypes and experiments and optimize components in their design phase to develop better reliable products.

Meshing

Meshing is a general-purpose, smart, automated high-performance product. Meshing is an integral part of the computer aided engineering simulation process. The mesh influences convergence, accuracy and speed of the solution. A mesh well suited for a specific analysis can be generated with a single mouse click for all parts in a model. In most of the cases meshing is the bottle neck for the analysis process often taking up the majority of the time in the project. Geometry quality can be directly related to the speed in which a mesh can be generated. Basic theme of finite element analysis is to make calculations at only limited number of points and then interpolate the results for entire domain. Any

continuous object has infinite degrees of freedom and it is just not possible to solve the problem in this format. Finite element method reduces degrees of freedom from infinite to finite with the help of discretization i.e. meshing.

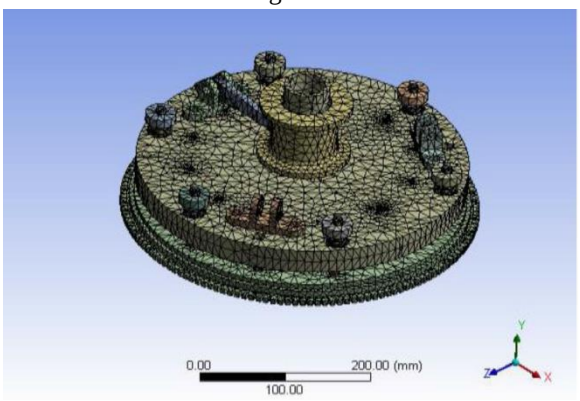

Fig 3. Meshing

Modal Analysis

Modal analysis is the study of the dynamic properties of systems in the frequency domain. A typical example would be testing structures under vibrational excitation. It is the field of calculating and analyzing the dynamic response of structures and/or fluids or other systems during excitation.

This analysis is considered essential step in the design process to estimate the vibration characteristics of the designed structure. Hence, the goal of a modal analysis is determining the natural frequencies and mode shapes. Modal analysis can also be taken as a basis for other more detailed dynamic analyses such as a transient dynamic analysis, a harmonic analysis or even a spectrum analysis based on the modal superposition technique. The main assumption in the modal analysis is that the system is linear and ignored nonlinearity in the system.

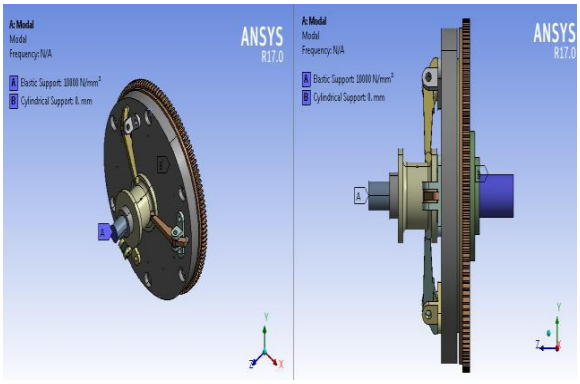

Fig 4. Modal Analysis

Result of Modal Analysis

The natural frequencies of original model which are provided by the customer are 171.15 Hz, 171.43 Hz, 333.54 Hz, 578.58 Hz, 1031.7 Hz, and 1033.3Hz. Modal analysis is done for simplified model and the mode shapes are found out.

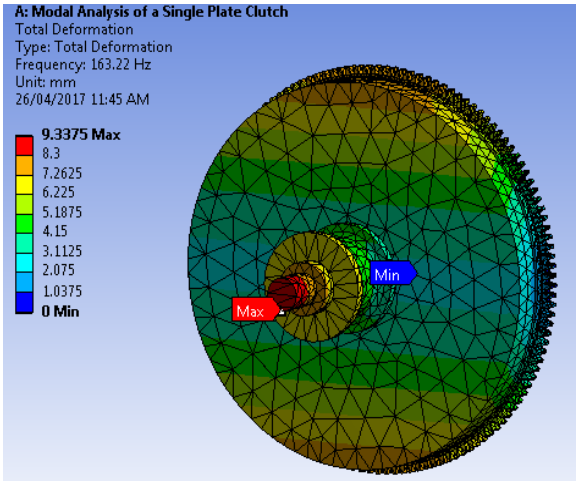

Fig 5.First mode shape (163.22Hz).2Hz)

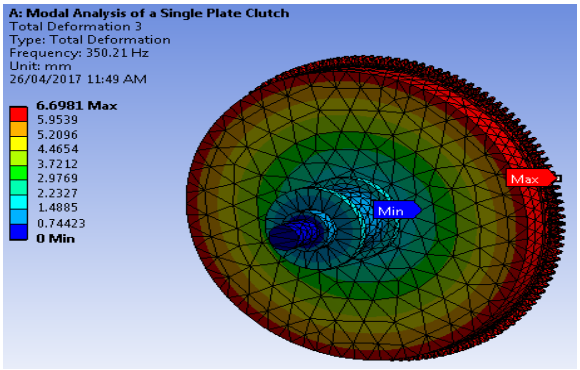

Fig 6. Second mode shape (350.21 Hz)

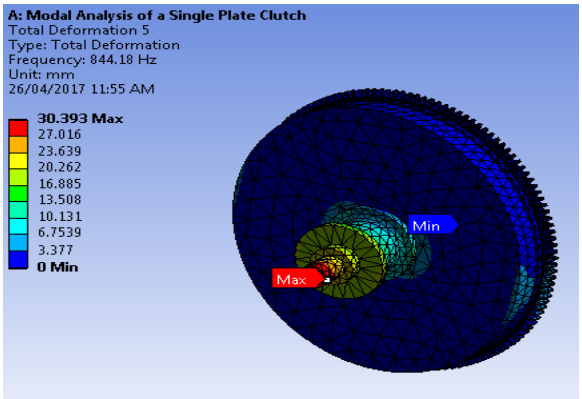

Fig. 7. Third mode shape (844.18Hz)

Following result are obtained by using the Simplified Model, The First Natural Frequency is observed as 163.22 Hz whereas the second Natural Frequency is observed as 350.21 Hz. Natural frequencies of

original model and natural frequencies of simplified model are in good agreement with each other.

V CONCLUSION

In the present work, the modal analysis and transient structural analysis were performed. The 3D model of clutch assembly was created in Pro-e software. Finite element analysis was carried out in ANSYS software. 3D model was built to obtain the optimal design parameters of the clutch.

The modal analysis of simplified clutch was performed to determine natural frequencies. The results show that natural frequencies of original model and natural frequencies of simplified model are in good agreement with each other.

REFERENCES

[1] O. I. Abdullah, J. Schlattmann, Emir Pireci, "Optimization of shape and design parameters of the rigid clutch disc using FEM", FME transactions,(2013),pp.317-324.

[2] Ali Belhocine, Wan Zaidi Wan Omar, "A numerical parametric study of mechanical behavior of dry contact slipping on disc pads interface" Alexandria engineering journal, (2016) 55, pp. 1127-1141.

[3] Vishal Deshbhratar, Nagnath Kakde, "Design and structural analysis of single plate friction clutch", international journal of engineering research and technology, (2013), vol.2, Issue 10.

[4] Animesh Agrawal, Ajay Kumar Verma, Siddharth Jaiswal, Ashutosh Pandey,Pratik Pandya, Ayush Shukla, Dr,S. K. Dhagat, "Optimization of multiplate friction clutch for maximum torque transmitting capacity using uniform wear theory", 12th global congress on manufacturing and management, (2014), pp.1089-10

[5] "Modelling And Assembly Of Single Plate Friction Clutch Of An Automobile" Dr.Prafull S. Thakre, volume 2, Issue II/ March, 12.PP1-4, Indian Streams Research Journal.