IJIREEICE ISSN (O) 2321-2004, ISSN (P) 2321-5526

International Journal of Innovative Research in Electrical, Electronics, Instrumentation and Control Engineering

Impact Factor 7.047 ⁜ Vol. 10, Issue 5, May 2022

DOI: 10.17148/IJIREEICE.2022.10513

DESIGN AND SHAPE OPTIMIZATION OF CLUTCH DISC OF PASSENGER CAR USING FEA AND FFT

Lunkad Sandeshkumar[1], Vishal Pawar[2], Rushikesh Jagdhane[3], Prof.Vivek Mohite[4]

Student, Dept. of Mechanical Engineering, JSPM's Bhivarabai Sawant Institute Of Technology & Research Pune, Maharashtra, India

Assistant Professor, Dept. of Mechanical Engineering, JSPM's Bhivarabai Sawant Institute Of Technology & Research Pune, Maharashtra, India

ABSTRACT: A friction clutch is an essential component in the process of power transmission. Due to this importance, it's necessary to investigate the stresses and vibration characteristics of the rigid clutch disc to avoid failure and obtain optimal weight and cost. This work presents the solution of computing the stresses and deformations during the steady-state period, as well as the vibration characteristics of the rigid clutch disc. Furthermore, new models for rigid clutch disc have been suggested. In this the materials of the clutch disc is same and vary the shape of optimization. The response of the new suggested models has been compared to the reference model. Three-dimensional CAD model of clutch disc is designed using CATIA V5R20. Finite Element Analysis (FEA) software ANSYS Version 19.0 is used to determine the total deformation and equivalent stresses, strain in clutch disc. Experimental investigation will be done by FFT analyzer and impact hammer test . Comparative analysis of FEA and Experimental will be done for validation of work. Conclusion and future scope will be suggested.

I. INTRODUCTION

A clutch is a mechanical device that engages and disengages power transmission, especially from a drive shaft (driving shaft) to a driven shaft. The clutch acts as a mechanical linkage between the engine and transmission; and briefly disconnects, or separates the engine from the drivetrain, and therefore the drive wheels, whenever the pedal is depressed, allowing the driver to smoothly change gears. 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 and other to power unit (the driving member). While the other shaft (the driven member) provides output power for work and typically the motions involved are rotary, linear clutches are also possible. In a torque-controlled drill, for instance, one shaft is driven by a motor, and the other drives a drill chuck. The clutch connects the two shafts so they may be locked together and spin at the same speed (engaged), locked together but spinning at different speeds (slipping), or unlocked and spinning at different speeds (disengaged).

A common application of the clutch is in automotive vehicles where it is used to connect the engine to the gearbox. The new direction of development of the automotive vehicle ride comfort and driving smoothness is associated with the advancement of the machine parts design, e.g., rigid clutch disc is considered as essential part to transfer torque from the driving to driven shaft in a way that is consistent with the comfort and robustness purposes. The main system of the friction clutch consists of pressure plate, clutch disc and flywheel as shown in figure 2. When the clutch starts to engage, slipping will occur between contact surfaces due to the difference in the velocities between them (slipping period). After this period all contact part are rotating at the same velocity without slipping (full engagement period).

A **clutch disc** can include springs which are designed to change the natural frequency of the **clutch disc**, in order to reduce vibration or audible rattling from the gearbox when the engine is idling in neutral. A **clutch** damper is a device that softens the response of the **clutch** engagement/disengagement

IJIREEICE ISSN (O) 2321-2004, ISSN (P) 2321-5526

International Journal of Innovative Research in Electrical, Electronics, Instrumentation and Control Engineering

Impact Factor 7.047 ⁜ Vol. 10, Issue 5, May 2022

DOI: 10.17148/IJIREEICE.2022.10513

II. LITERATURE SERVEY

] "clutch assembly modelling and dynamic analysis" by GOWTHAM MODEPALLI. Amrita Vishwa Vidyapeetham University, Coimbatore (2015), International Journal of Mechanical and Production Engineering, ISSN: 2320-2092, Volume- 3, Issue-11, Nov.-2015.

In this literature author study on modelling and dynamic analysis of clutch assembly with the help of ANSYS software. Clutches are useful in devices that have two rotating shafts. In these devices, one of the shafts is typically driven by a motor or pulley, and the other shaft drives another device. The clutch connects the two shafts so that they can either be locked together and spin at the same speed, or be decoupled and spin at different speeds. In evaluating the stresses and strain in the part, modelling and simulation are used. The modelling of the clutch assembly is modelled using 3D software. Here we will be using Pro E for modelling. The simulation part will be carried out using the Analysis software, ANSYS. Analysing results for clutch assembly under moment and rotational velocity are listed in the Table. Analysis has been carried out by asbestos and alumina. The results such as total deformation, equivalent elastic strain, equivalent stress, temperature distribution for each material is determined.

[3.2] "design and analysis of an automotive single plate clutch" by Sunny Narayan, Ivan Grujic, Nadica Stojanovic, Kaisan Muhammad Usman, Abubakar Shitu, Faisal O. Mahroogi. Received in February 2018 Revised 23 February 2018 Accepted 2 April 2018.

This paper presents the stresses and deformations of the assembly of the automotive single plate clutch depending on the applied materials. A clutch is a machine member used on the transmission shafts. Some friction plates, sometimes known as clutch plates are kept between these two members.

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. Generated Heat between friction disk and flywheel, which is the main reason for clutch wear can be minimized by selecting suitable material. A good contact pressure also reduces wear during slippage time.

[3.3] "Modelling and Stability Analysis of Wedge Clutch System" by Jian Yao, Li Chen, and Chengliang Yin. Hindawi Publishing Corporation Mathematical Problems in Engineering Volume 2014, Article ID 712472, 12 pages.

With the rising demand of improving vehicle economy, the electrification is a clear tendency in modern transmission system. dual clutch transmission, and so forth. Among these, the wedge-based clutch actuator, featuring self-reinforcement function, offers good opportunity to obtain large normal force by small actuation force. Therefore, the wedge clutch can be space-saving and energy-saving and satisfy the requirement of automotive electronics applications relying on the low voltage batteries.

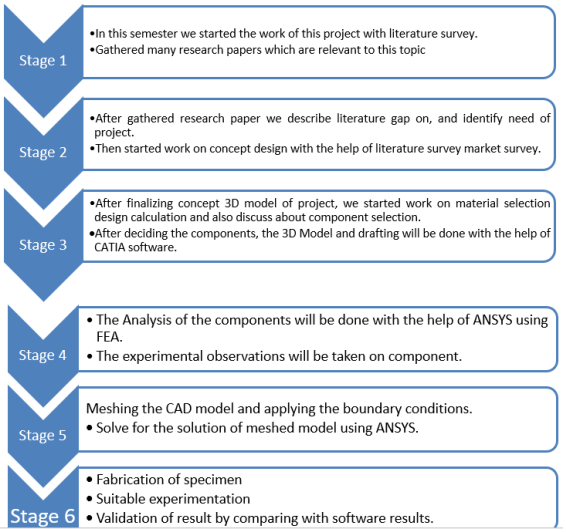
The wedge-based clutch actuation system with self-reinforcement feature brings stability problem and different dynamic behaviour. To analyse this system, a complete mathematical model is built including its DC motor, wedge mechanism, and clutch pack. And the model is linearized by considering the clutch slipping stage with steady state friction coefficient.

[3.4] "Coordinated Control of Downshift Powertrain of Combined Clutch Transmissions for Electric Vehicles" by Junqiu Li and Han Wei. National Engineering Laboratory for Electric Vehicles, Beijing Institute of Technology, Beijing 100081, China, received 6 March 2014; Accepted 11 May 2014; Published 1 June 2014.

In this article author explain about Coordinated Control of Downshift Powertrain of Combined Clutch Transmissions for Electric Vehicles. Electric vehicles (EVs) are paid wide attention to on account of deteriorated environment and energy crisis in recent years. The characteristics of wide working range, constant torque at low speed, and constant power at high speed make the motor suitable for vehicles, and transmissions can be removed in theory. Even so, large EVs still need transmissions with fewer gears to keep climbing performance and high-speed performance in balance.

IJIREEICE ISSN (O) 2321-2004, ISSN (P) 2321-5526
International Journal of Innovative Research in Electrical, Electronics, Instrumentation and Control Engineering
Impact Factor 7.047 ⁜ Vol. 10, Issue 5, May 2022
DOI: 10.17148/IJIREEICE.2022.10513

III. METHODOLOGY



OPERATION OF CLUTCH:

Motorcycle manufacturers usually employ a stack of alternating plain steel and friction plates. These are stacked in alternating fashion to what is known as a basket clutch. Typically, some of the friction plates would have lugs on the outer diameter of the plate to lock it onto a 'basket' that is responsible for turning the input shaft of the transmission. When the clutch is disengaged, which is done by pulling the lever on the left of the handlebar, a taut cable, with the help of links, moves the entire system of plates away from each other and forms a gap between the plates so as not to transfer power to the successive plates and eventually reach the clutch housing. In this case, the clutch housing would be free from any force and the flywheel at the end of the engine would be spinning freely.

Release the clutch (letting go of the lever on the left), the clutch plates (friction plates press against the steel plates) are pressed onto each other by several springs housed on the clutch housing and this action directly engages the clutch with the engine via the flywheel and power is transmitted. Modern motorcycles are equipped with several friction and steel plates and the entire unit is known as the Multiplate Clutch.

Another reason why a clutch is essential on a motorcycle is that it helps the rider to select the right gear while moving. Setting the motorcycle from Neutral to First requires the clutch and similarly at every gear change. Shifting without disengaging the clutch can cause problems to the transmission and may damage the cog wheels.

The clutch plates are prone to degradation but most modern bikes are equipped with clutch plates that can last quite a number of years, if maintained and used properly. Wet Clutches are harder to maintain as they are housed inside the engine casing and should make sure that the oil is fully contained before working on any element of the engine.

EXPERIMENTAL TESTING:

Fast Fourier Transform

FFTs were first discussed by Cooley and Tukey (1965), although Gauss had actually described the critical factorization step as early as 1805 (Bergland 1969, Strang 1993). A discrete Fourier transform can be computed using an FFT by means of the Danielson-Lanczos lemma if the number of points N is a power of two. If the number of points N is not a power of two, a transform can be performed on sets of points corresponding to the prime factors of N which is slightly degraded in speed. An efficient real Fourier transform algorithm or a fast Hartley transform (Bracewell 1999) gives a further increase in speed by approximately a factor of two. Base-4 and base-8 fast Fourier transforms use optimized code, and can be 20-30% faster than base-2 fast Fourier transforms. prime factorization is slow when the factors are large, but

IJIREEICE ISSN (O) 2321-2004, ISSN (P) 2321-5526
International Journal of Innovative Research in Electrical, Electronics, Instrumentation and Control Engineering
Impact Factor 7.047 ⁜ Vol. 10, Issue 5, May 2022
DOI: 10.17148/IJIREEICE.2022.10513

discrete Fourier transforms can be made fast for $N = 2$, 3, 4, 5, 7, 8, 11, 13, and 16 using the Winograd transform algorithm.

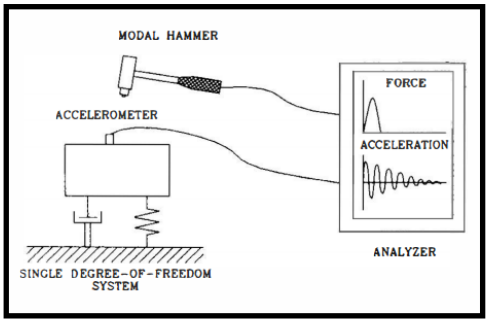
The experimental validation is done by using FFT (Fast Fourier Transform) analyzer. The FFT spectrum analyzer samples the input signal, computes the magnitude of its sine and cosine components, and displays the spectrum of these measured frequency components. The advantage of this technique is its speed. Because FFT spectrum analyzers measure all frequency components at the same time, the technique offers the possibility of being hundreds of times faster than traditional analog spectrum analyzers.

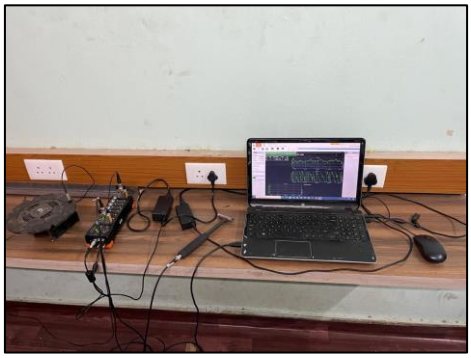
Fourier analysis of a periodic function refers to the extraction of the series of sines and cosines which when superimposed will reproduce the function. This analysis can be expressed as a Fourier series. The fast Fourier transform is a mathematical method for transforming a function of time into a function of frequency. Sometimes it is described as transforming from the time domain to the frequency domain. It is very useful for analysis of time-dependent phenomena.

Impact Hammer Test

Impact excitation is one of the most common methods used for experimental modal testing. Hammer impacts produce a broad banded excitation signal ideal for modal testing with a minimal amount of equipment and set up. Furthermore, it is versatile, mobile and produces reliable results. Although it has limitations with respect to precise positioning and force level control, overall its advantages greatly outweigh its disadvantages making it extremely attractive and effective for many modal testing situations.

The use of impulse testing with FFT signal processing methods presents data acquisition conditions which must be considered to ensure that accurate spectral functions are estimated. Problems stem from the availability of only a finite duration sample of the input and output signals. When a structure is lightly damped the response to the hammer impact may be sufficiently long that it is impractical to capture the entire signal. The truncation effect manifests itself in terms of a spectral bias error having the potential to adversely affect the estimated spectra. The signal truncation problem is further compounded in practice by the computational and hardware constraints of the FFT processing equipment. Typically the equipment has a limited number of data capture lengths or frequency ranges which are available for an operator to select. Normally a user is more concerned with useable analysis frequencies and less with the data capture length.





IJIREEICE ISSN (O) 2321-2004, ISSN (P) 2321-5526

International Journal of Innovative Research in Electrical, Electronics, Instrumentation and Control Engineering

Impact Factor 7.047 ⁜ Vol. 10, Issue 5, May 2022

DOI: 10.17148/IJIREEICE.2022.10513

IV. RESULT AND DISCUSSION

- Optimization of the clutch disc done by using CATIA software and analysis of the clutch disc completed using ANSYS software.
- Find out natural frequency of the clutch disc using modal analysis with the help of ansys software.
- The main aim is to weight optimization of the clutch disc without affecting the fundamental frequency of the disc.

V. CONCLUSION

- In this project completed 2 optimized design using catia software for the weight optimization.
- The vibration analysis of the existing and optimized model completed using ANSYS software. The fundamental frequency of the existing clutch disc is 129.30 Hz. And the weight of existing clutch disc is 1.59 kg.
- Iteration 1 - The fundamental frequency of the optimized clutch disc is 123.31 Hz with the weight 1.50 kg.
- Iteration 2 - The fundamental frequency of the optimized clutch disc is 123.31 Hz with the weight 1.46 kg.
- The weight reduction using topology optimization technique is 130 gram, which is 8.17 %.
- The experimental validation perform using FFT technique and the fundamental frequency of the experimental testing is 136.7 Hz.

VI. REFERENCES

[1] Amrita Vishwa Vidyapeetham University, Coimbatore (2015) “clutch assembly modelling and dynamic analysis” by GOWTHAM MODEPALLI. , International Journal of Mechanical and Production Engineering, ISSN: 2320-2092, Volume- 3, Issue-11, Nov.-2015.

[2] Sunny Narayan, Ivan Grujic, Nadica Stojanovic, Kaisan Muhammad Usman, Abubakar Shitu, Faisal O. Mahroogi. “design and analysis of an automotive single plate clutch” Received in February 2018 Revised 23 February 2018 Accepted 2 April 2018.

[3] Jian Yao, Li Chen, and Chengliang Yin “Modelling and Stability Analysis of Wedge Clutch System” . Hindawi Publishing Corporation Mathematical Problems in Engineering Volume 2014, Article ID 712472, 12 pages.

[4] Junqiu Li and Han Wei “Coordinated Control of Downshift Powertrain of Combined Clutch Transmissions for Electric Vehicles” . National Engineering Laboratory for Electric Vehicles, Beijing Institute of Technology, Beijing 100081, China, received 6 March 2014; Accepted 11 May 2014; Published 1 June 2014.

DOI: 10.17148/IJIREEICE.2022.10513

[5] Asst.Prof.K.Adithya S.Satheeshkumar S.Thirunavukarasu D.Vignesh T.Vishnu Paramesh "Design and Analysis of Disc in Clutch Plate By Replacing the Conventional Material" International Journal of Engineering Research & Technology (IJERT) Special Issue - 2017.

[6] Sunny Narayan 1, Ivan Grujic, Nadica Stojanovic, Kaisan Muhammad Usman, Abubakar Shitu, Faisal O. Mahroogi "Design and analysis of an automotive single plate clutch". Received in February 2018 Revised 23 February 2018 Accepted 2 April 2018.

[7] Neupert, Thomas, Benke, Elisabeth, Bartel, Dirk "Parameter study on the influence of a radial groove design on the drag torque of wet clutch discs in comparison with analytical models". Institute of Machine Design, Otto von Guericke University Magdeburg, Universitaetsplatz, 39106 Magdeburg, Germany.

[8] "Design optimization of clutch cushion disc with the integration of finite element analysis and design of experiments" by Vivek Thacker1 and E Vijayaragavan. Department of Mechanical Engineering, SRM IST, Kattankulathur – 603203.

[9] "Investigation on the failure mechanism and safety mechanicalthermal boundary of a multi-disc clutch" by Liang Yua, Biao Maa, Man Chena, Heyan Lib, Jikai Liuc, Mingyang Li. College of Urban Transportation and Logistics, Shenzhen Technology University, Shenzhen 518118, China.