

A Mutidisk Clutch Design & Performance Optimization Using Anova Method

M. Tech. Scholar Shubham Verma, Asst. Prof. G. R. Kesheorey

Dept. of Mechanical Engg.
Vindhya Institute of Technology and Science,
Indore (M.P.)

Abstract- Multi plate clutch is one of the important part in the power transmission systems. Good design of clutch provides better engine performance. Multi plate clutch is most widely used in racing cars and heavy duty vehicle where high torque transmission required and limited space is available. In this project, we have 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 workbench for Structural Applications. We have conducted structural analysis by varying the friction surfaces material and keeping base material as Steel. By observing the results, comparison is done for materials to validate.

Keywords- Multi-Plate Clutch, Friction Material, SF-MC2, CATIA V5.

I. INTRODUCTION

A clutch is one of the mechanical devices which is used for connecting or disconnecting a pair of rotating coaxial shafts. And it is generally Placed between the driving motor to the driven motor of a machine where permitting the engine to be started in an unloaded condition. Single plate, dry clutch is one along with the fashionable type of clutches in today use. A clutch is a mechanism designed to connect and reconnecting the driving and driven members and enables one rotary drive shaft to be joined to the another shaft, or when there is relative motion between them. The requirement of clutch mostly seems for the uniqueness of the revolving effort developed by the engine by its lower speed. In idling condition, the engine develops a lacking torque for the transmission for positive engage.

In turn to attain a smooth engagement, the clutch have to be progressively engaged to take up the drive until the torque transmitted from the engine generation that essential to propel the vehicle and also the clutch disconnects the engine from the transmission to change the gear. The clutch takes up the drive efficiently and also disengages the drive whenever necessary.

Clutches are required when shafts must be frequently connected and disconnected. The function of a clutch is: first, to provide a gradual increase in the angular velocity of the driven shaft, so that its speed can be brought up to that of the driving shaft without shock; second, when the two shafts are rotating at the same angular velocity, to act as a coupling without slip or loss of speed in the driving shaft.

1. Clutch Systems:

A clutch system can transmit torque or rotation between shafts by engaging, while the input shaft is driven by the

engine and the output shaft is connected to the transmission or some other device. A clutch device links these two rotating shafts to be connected together and rotate with the same speed, or be separated and rotate at different speeds.

A clutch is very important for the performance of automatic transmissions. Though the machine components in most of the applications are designed to experience low friction, for clutches a higher friction is a primary necessity. A clutch can be wet (lubricated) or dry. The wet clutch has a steady supply of filtered oil that keeps the clutch interfaces cool. Moreover, a wet clutch is immersed in a cooling lubricating fluid, therefore, the clutch interfaces are kept dirt free and provides smoother performance and longer service life.

In contrast, no lubricant is used for dry clutch operations. Though a dry clutch can engage more rapidly than a wet clutch and the shifting process is relatively fast it does not offer the above mentioned advantages with cooling, clean and noise-free operation as a wet clutch. As a result, the dry clutch is also less durable and can serve for a shorter life period than the wet clutch.

Addis Ababa Institute of Technology, School of Mechanical and Industrial Engineering is to develop a light weight and Green vehicle which is robust, environmentally friendly, and supporting the advancement of green area protocol.

The existing commercial clutch plate (Disc) material (i.e. Gray Cast Iron) weight which is 4.5-6 kg is a major issue in design of MPCs. But, the green vehicle to be developed would have to have lighter weight and lighter component parts. Therefore, to overcome those problems this paper was proposed and done to investigate a better lining

material and design of appropriate MPCs, for use in TCT system for a Green, and light weight vehicles.

2. Types of Clutches:

The two main types of clutches commonly used in engineering practice are:

- Positive clutches.
- Friction clutches.

3. Materials:

The friction material is very similar to the material used in brake shoes and pads and contained asbestos in the past. Also, clutches found in heavy duty applications such as trucks and competition cars use ceramic clutches that have a greatly increased friction coefficient, however these have a "grabby" action and are unsuitable for road cars [6].

Structural analysis for clutch plate has done using the properties of three materials which are used for liner (i.e. carbon-carbon composites, Kevlar, Ceramic composites) [6].

In this cited paper comparison is done for above materials to validate better lining material for clutch plate, and also validates and made analysis on other materials used for clutching system. This helps to identify appropriate materials to be used for clutch design.

II. RESEARCH MOTIVATION

A significant majority of production vehicles with automatic transmissions on the road today use either a planetary automatic transmission (AT) or a dual clutch transmission (DCT).

Dual clutch transmissions, by design, employ two actively controlled plate friction clutches, capable of transmitting the load in both slip speed directions, to implement a gearshifts; making all shifts clutch-to-clutch shifts.

On the other hand, planetary automatic transmissions usually employ a combination of friction clutches, which may be plate clutches or band clutches, and one-way clutches for activation during gearshifts.

III. LITERATURE REVIEW

Md. Abu Ayub Siddique, Simulation of Design Factors of a Clutch Pack for Power-Shift Transmission for an Agricultural Tractor: The objective of this study is the simulation of the most affected design factors and variables of the clutch pack for the power-shift transmission (PST) of a tractor based measured data.

The simulation model, the mathematical model of sliding velocity, a moment of inertia, and clutch engagement pressure of clutch pack were developed using the powertrain and configurations of the real PST tractor.

In this study, the sensor fusion method was used to precisely measure the proportional valve pressure by test bench, which was applied to the simulation model.

The clutch engagement times were found 1.20 s at all temperatures for determined factors. The engagement pressures have a significant difference at various temperatures (25 to 100 °C) of the hydraulic oils after the 1.20 s but the most affected factors were satisfied with the simulation conditions that ensure the clutch engagement on time.

Finally, this sensor fusion method is believed to be helpful in realizing precision agriculture through minimization of power loss and maximum energy efficiency of tractors.

Jinsung Kim, Design and Modeling of a Clutch Actuator System With Self-Energizing Mechanism:

The engineering technology for automotive systems is currently edging toward improving fuel economy. Transmission is one of the major parts to determine overall energy efficiency. The goal of this paper is to investigate the feasibility of a new clutch actuator in order to increase power transmitting efficiency. The new clutch actuator has self-energizing mechanism to amplify the normal force applied on the contact surfaces for the engagement. It allows the clutch module to consume less amount of energy for actuating the overall system.

The equations of motion of the clutch mechanism coupled with a dc motor are represented to capture the essential dynamics. By using the proposed model, a model-based position-tracking controller is developed for the engagement of the clutch. Also, passivity analysis of the actuator system is performed to prevent the clutch from being stuck. Finally, the self-energizing effect and torque transmissibility of the proposed system and motion controller are validated experimentally.

Oday I. Abdullah, Optimization of Shape and Design Parameters of the Rigid Clutch Disc Using FEM:

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 numerical 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.

The response of the new suggested models have been compared to the reference model. The numerical results show that the stresses and vibration characteristics of rigid clutch disc can be controlled by adjusting design parameters. They show as well that the suggested models improve the response of the friction clutch considerably. The ANSYS/WORKBENCH14 and SolidWorks 2012

have been used to perform the numerical calculation in this paper.

IV. WORKING PRINCIPLE OF MULTI-PLATE CLUTCH

To discuss the working principle of the multi-plate clutch, it can be said at first that it has two types of working procedures. One is the engaging procedure and the other is the disengaging procedure. Regarding this, here the two types are discussed below:

1. Engage:

- Engagement takes place in the engine when the driver pressed the clutch paddle.
- Apart from that, it enhances the movements of the thrust springs.
- The pressure can be given to give pressure to the pressure plates with the help of thrust springs.
- Hence, the pressure plate tends to move forward.
- Along with that, the friction linings that are attached on the inner side of the pressure plate to make contact with the flywheel, start its action.
- As a result, the clutch engages.

2. Disengage:

- For disengaging the clutch and the engine of the vehicle, the driver has to press the clutch pedals as well as the fins of inner splined sleeves at first.
- It enhances the thrust spring to move backward.
- This thrust spring releases pressure from the pressure plates.
- Hence, the pressure plate tends to move backward.
- As a result of removing the pressure from the flywheel, pressure plate and springs the clutch becomes disengaged.

3. Advantages of Multi-Plate Clutch:

There are many advantages of the Multi Plate clutch. Some of the advantages are stated below:

- As the multi-plate clutches are made of more clutch plates so the capacity of transmission of torque is quite high.
- This type of clutch is small in size. Due to its compact size, the multi-plate clutch is suitable for any sort of vehicles around the globe. As the motorcycles and scooters have limited space, so the multi-plate clutch can be fitted easily because of its compact size.
- In comparison with the single-plate clutch, the diameter of the multi-plate clutch is smaller than the single-plate. Due to this feature, the multi-plate clutch can be used in many sports such as racing and others.
- The multi-plate clutches have many friction surfaces. As the transmission of torque depends on the number of friction surfaces, so in the case of the multi-plate clutch, torque becomes higher than the single-plate clutch.

V. ANALYSIS OF VARIANCE (ANOVA) HAS THREE TYPES

1. One Way Analysis:

When we are comparing more than three groups based on one factor variable, then it said to be one way analysis of variance (ANOVA). For example, if we want to compare whether or not the mean output of three workers is the same based on the working hours of the three workers.

2. Two Way Analysis:

When factor variables are more than two, then it is said to be two way analysis of variance (ANOVA). For example, based on working condition and working hours, we can compare whether or not the mean output of three workers is the same.

3. K-Way Analysis:

When factor variables are k, then it is said to be the k-way analysis of variance (ANOVA).

Key terms and concepts:

4. Sum of Square Between Groups:

For the sum of the square between groups, we calculate the individual means of the group, then we take the deviation from the individual mean for each group. And finally, we will take the sum of all groups after the square of the individual group.

5. Sum of Squares Within Group:

In order to get the sum of squares within a group, we calculate the grand mean for all groups and then take the deviation from the individual group. The sum of all groups will be done after the square of the deviation.

VI. METHODOLOGY OF RESEARCH

Some basic procedures that will be followed in order to fulfill the objectives of the thesis are stated below:

- Identifying the material types considering cost, availability, and their weight.
- Calculation of stresses, and maximum pressures using Euler-Lagrange equations.
- Developing 3D model of MPCs using CATIA software. Exporting the model of MPCs from solid work 16 to CATIA work bench for FEA.
- Static and dynamic analysis of MPCs using CATIA work bench at different operating condition.
- Determining the wear, maximum deformation and equivalent stresses for each material using FEA.
- Showing the relation of deformation and resistance property of each material using figures and tables. Comparing and discussion of results for selection of better lining materials. All the above procedures have been conducted with application of a specified conditions and constraints that helps to get the suitable and reliable result.

VII. RESULT AND SIMULATION

1. Models of Multi Plate Clutch Using:

The multi plate clutch is modeled using the given specifications and design formula from data book. The isometric view of multi plate clutch is shown in below figure. The multi plate clutch outer casing body profile is sketched in sketcher and then it is extruded by using extrude option.

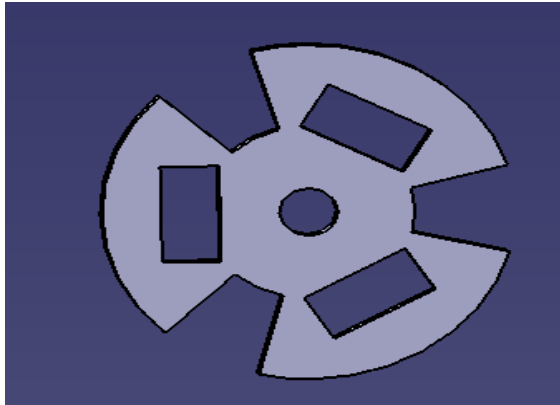


Fig 1. Clutch plat 1.

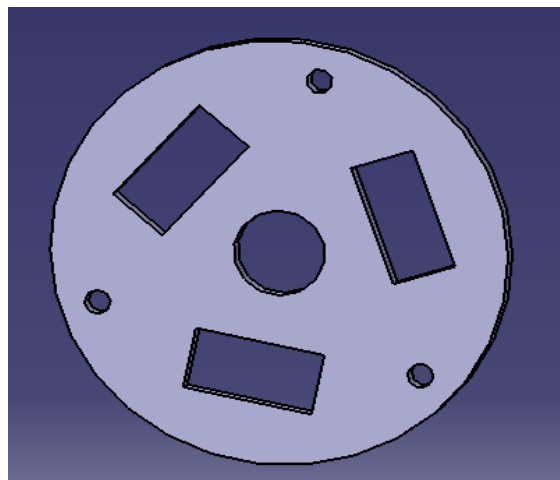


Fig 2. Clutch plat 2 Multi plat.

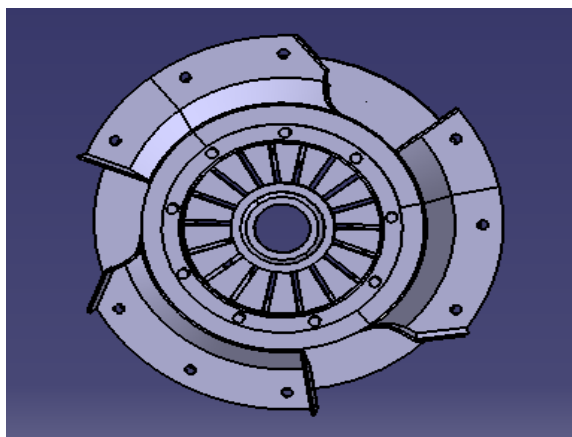


Fig 3. Assembly of clutch.

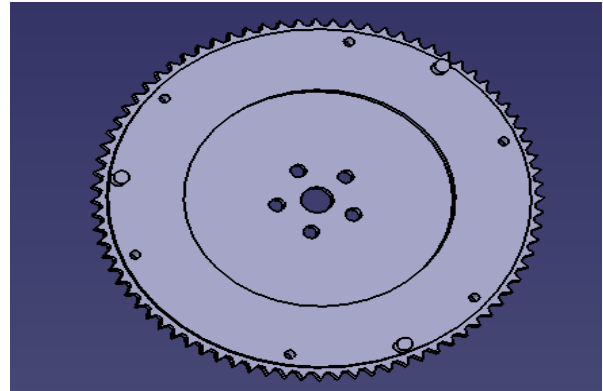


Fig 4. Connecting disc.

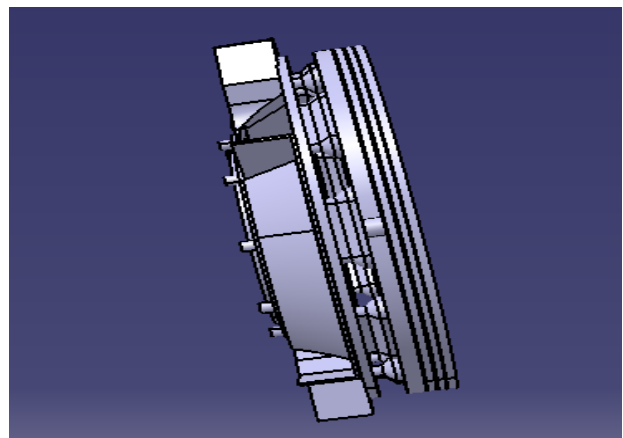


Fig 5. Assembly of clutch side view.

Table 1. Material Table.

Material	Nickel
Young's modulus	2.14e+011N_m2
Poisson's ratio	0.31
Density	8880kg_m3
Coefficient of thermal expansion	1.31e-005_Kdeg
Yield strength	5.9e+007N_m2

Table 2. Structure Computation.

Number of nodes	5321
Number of elements	2756
Number of D.O.F.	15963
Number of Contact relations	0
Number of Kinematic relations	0
Parabolic tetrahedron	2756

Table 3. Structural mass Computation.

Number of lines	15963		
Number of coefficients	563934		
Number of blocks	2		
Maximum number of coefficients per bloc	499992		
Total matrix size	6	51	Mb

Structural mass : 8.147e-002 kg

Inertia center coordinates:

Xg : -7 . 877e-003 mm

Yg : 4 . 660e-004 mm

Zg : 1 . 500e+000 mm

Inertia tensor at origin: kgxm2

2.765e-005	1.062e-008	1.535e-009
1.062e-008	2.765e-005	-4.805e-010
1.535e-009	-4.805e-010	5.482e-005

Table 4. ANOVA Result.

Probability Output	
Percentile	Stretch
10	0
30	0
50	0.339
70	0.521
90	2756

Table 5. Regression Statistics.

Regression Statistics	
Multiple R	0.577019
R Square	0.332951
Adjusted R Square	0.082951
Standard Error	1125.455
Observations	5

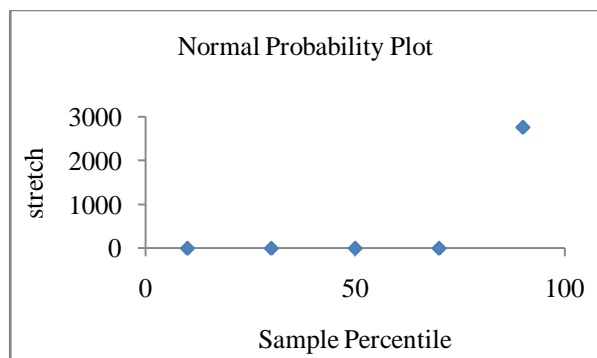


Fig 6. Normal Probability plot.

VIII. CONCLUSION

After completion of the analysis in CAE software i.e. CATIA based on the values of Equivalent stresses for material loading conditions it is clearly seen that these are less than the allowable stresses for that particular material under applied conditions the part not going to yield and hence the design is safe. The result occurred are quiet favorable which was expected. The stresses as well as deformation clear the idea about what parameter should have been taken into account while defining the single plate friction clutch.

From the literature review it can be concluded that the conventional disc brake system can perform braking within a short distance and time. From the theoretical analysis it is found that the brake force required to stop or to minimize the speed of the wheel is less in case of the peripheral disc as compared to the conventional disc brake. From the theoretical analysis it is concluded that the brake force does not passes through the wheel through spokes in case of the peripheral disc brake system. Design of the spokes can be optimized.

REFERENCES

- [1] Ting-Long Ho., 1974. "Effect of frictional heating on brake materials", Wear, 30(1974) 73-91
- [2] Masahiro Kubota., 2000. "Development of lightweight brake disc rotor: A design approach for achieving an optimum thermal, vibration and weight balance." JASE review 21 (2000) 349-355.
- [3] Ji-Hoon Chio, 2003. "Finite element Analysis of transient thermo elastic-behaviours in disk brakes", Wear, 257 (2004) 47-58.
- [4] JIANG Lan, 2011, "Thermal analysis for brake disk of Sci/6061 Al. Alloy co-continuous composite for CRH3 during emergency braking considering air flow cooling", Trans. Nonferrous Met. Soc. China 22(2012) 2783-2791.
- [5] Oder G., "Thermal and stress analysis of brake discs in railway vehicles", Advance Engineering 3(2009), ISSN: 1846-5900.
- [6] Faramarz talati, 2009. "Analysis of heat conduction in a disk brake system", Spinger-Velag2009.
- [7] Ziad, 2009. "An investigation of disc brake rotor by FEA."ISSN: 1985-3157, Vol.3, No. 2, JulyDec 2009.
- [8] Adam Adamowicz, 2011. "Analysis of disc brake temperature distribution during single braking under non-axisymmetric load", Applied thermal engineering 31(2011) 1003-1012.
- [9] Ali Belhocine, 2012 "Thermal analysis of a solid brake disc", Applied thermal engineering 32(2012) 59-67.
- [10] Harpal Singh, 2012. "Thermal Analysis of disk brake using COMSOL", International journal on Engineering technologies ISSN No. 2249-3255.