Design and Analysis of Clutch Plate Using Steel Material

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Abstract—Clutch plates are usually made of cast iron and high carbon steels. The properties of cast iron have high compressive strength, low tensile strength and no ductility. It can be easily machined. Due to this reason, it is suitable for the clutch plate but its cost is high. In order to reduce the cost of clutch plate material without affecting the life and effectiveness of the clutch plate, we modify other material low carbon steel for clutch plate. Comparison can be done for deformation, stresses etc. form the three materials to check which material is best. NX/UG is a 3d modeling software widely used in the design process. HYPERMESH is general-purpose finite element analysis (FEA) software package. Finite Element Analysis is a numerical method of deconstructing a complex system into very small pieces (of user-designated size) called elements.

Keywords—Clutch Plate and Finite Element Analysis (FEA).

I. INTRODUCTION

Clutch is a mechanism which enables the rotary motion of one shaft to be transmitted, when desired, to a second shaft the axis of which is coincident with that of the first. A clutch plate is a main component in the clutch mechanism of the automobile vehicle. The usage is increased due to replacement of worn out clutches frequently.

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.

A Clutch is a mechanism designed to disconnect and re-connect the 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 a relative motion between them. The main function of the clutch is to enable smooth transmission of a rotary motion of a engine crankshaft to a stationary or slowly revolving output shaft(gearbox shaft) without snatch and it also enables rapid disengagement and re-engagement of the engine from the transmission while one or both in motion, for gear changing and emergency stops.

The material which is used in this pressure plate is grey cast iron (FG300). The property of grey cast iron has high hardness, low tensile strength, no ductility and it can be easily machined. We analyzed this material to obtain the stress in the pressure plate.

After obtaining the values, we use different materials but with suitable properties to obtain a better stress and functions of pressure plate. Hence, we use steel En GJS-400-15 as optional material to grey cast iron. These materials also have similar properties of grey cast iron. We analyze these two materials to obtain the stress in the materials. Then, we compare the stress values of all materials and take out the best. The advantage of this project is to reduce the cost of clutch plate without affecting the function and life of clutch plate.

There are two types of demand for Clutch Plates1 O.E.Demand and 2.Replacement demand. The O.E Demand will increase with the production of original vehicles. The replacement demand is dependent on the wear and tear and replacement of the vehicle owners as this is a critical equip-ment and replacement is essential to run the vehicle, the replacement demand is bound to increase. With the setting up major automobile projects namely Ford Motors,

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Hyundai Motors, Hindustan Motors, Mitsuibishi and with expansion plans of Ashok Leyland TAFE, Chennai emerges the Detroit of south East Asia. TamilNadu has always been a fore-runner in the industrial process, both in terms of industrial output and also terms of encouraging various new large-scale projects.

The clutch disc is generally made from grey cast iron (Af-ferante et al. 2003; Poser et al. 2005). This is because grey cast iron has a good wear resistance with high thermal conductivity and the production cost is low compare to other clutch disc ma-terials such as A1-MMC (aluminum-metal matrix composite), carbon composites and ceramic based composites (Terhech et al. 1995; Jang et al. 2003). High thermal conductivity of diffusivity of the material is considered advantageous because heat is then allowed to dissipate at higher rate (Bostwick and Szadkowski 1998).

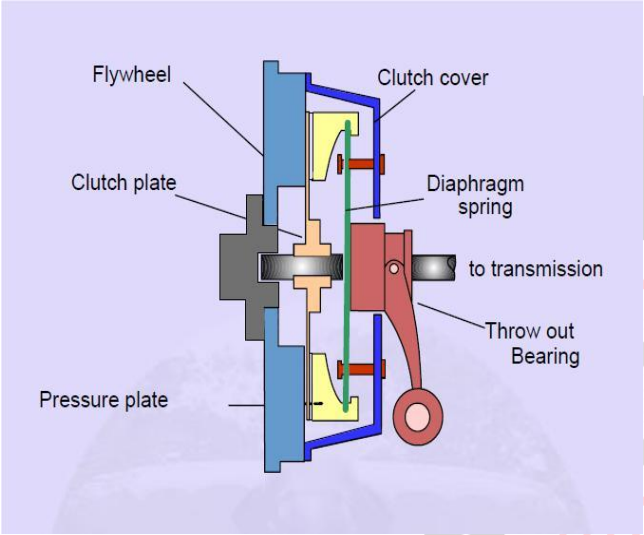

Fig. 1. Schematic Diagram for Clutch Plate

II. LITERATURE REVIEW

Hisanao Kitabayashi, Chen Yu Li and Henry Hiraki [1] were conducted experiments to study the effects of design factors of clutch packs on drag torque. From the test results, the design factors with a large effect were facing area and wave height. At high rotational speeds, automatic transmission fluid (ATF) flow rates and the number of grooves also had a significant effect. At low rotational speeds, since drag torque increased linearly with increasing speed, the results were compared to calculated values using theoretical equations based on Newton's law of viscosity. Furthermore, it was confirmed through visualization experiments of ATF flow on the rotating facing surface that the ATF completely covered the surface at low rotational speeds and that air mixed with the ATF at high rotational speeds.

Kavlicoglu, Barkan M and Gordaninejad, [2] are focuses on the design and characterization of a radial double-plate magneto-rheological fluid (MRF) clutch. The clutch's torque output can be controlled by adjusting the applied magnetic field. Electromagnetic finite element analysis (FEA) is per-formed to design and optimize the clutch. The shear stress dis-tribution in MRF between the plates is theoretically predicted using the magnetic flux density distribution evaluated from the FEA. The output torque of the clutch is derived by using the Bingham plastic constitutive model. The output torque values are recorded for different input velocities and applied magnetic fields, and they are compared with the theoretical results. It was demonstrated that the clutch is capable of producing high controllable torques.

Rajesh Purohit [3] deals with designing a friction clutch assembly using Solid Works Office Premium software. The assembly comprises of the clutch plate, the pressure plate and a diaphragm spring. Static structural analysis was done using ANSYS software. The plots for equivalent stress, total deformation and factor of safety were obtained and the design was continuously optimized till a safe design was obtained. Uniform wear theory was used for the analysis. The material assignment is as follows: clutch plate- structural steel, pressure plate- cast iron GS-70-02 and diaphragm spring- spring steel. The friction material assumed is molded asbestos opposing cast iron/ steel surface.

Rajesh Purohit and Rakesh Sagarare worked on [4] Alu-minum matrix composites are finding increased application in automotive, aircraft and aerospace industries and hold the greatest promise for the future growth. In the present work an attempt has been made to access the opportunity for Al-SiCp composites as an alternative material for the poppet valve guides. The finite element analysis of the Al-SiCp composite poppet valve guide was done using Ansys software. The temperature, principal stress and principal strain distribution over the entire surface of the poppet valve guide were obtained. The stresses were found to be well below the allowable stress for the Al-SiCp composites.

Jinsung Kim ; Seibum B. ChoiThe [5] engineering tech-nology 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.

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III. FINITE ELEMENT ANALYSIS

Finite Element Analysis (FEA) was first developed in 1943 by R. Courant, who utilized the Ritz method of numerical analysis and minimization of variational calculus to obtain approximate solutions to vibration systems. Shortly thereafter, a paper published in 1956 by M. J. Turner, R. W. Clough, H. C. Martin, and L. J. Topp established a broader definition of numerical analysis. The paper centered on the ”stiffness and deflection of complex structures”.

By the early 70’s, FEA was limited to expensive mainframe computers generally owned by the aeronautics, automotive, defense, and nuclear industries. Since the rapid decline in the cost of computers and the phenomenal increase in computing power, FEA has been developed to an incredible precision. Present day supercomputers are now able to produce accurate results for all kinds of parameters.

The finite element is a mathematical method for solving ordinary and partial differential equations. Because it is a numerical method, it has the ability to solve complex problems that can be represented in differential equation form. As these types of equations occur naturally. In virtually all fields of the physical sciences, the applications of the Finite element method are limitless as regards the solution of practical

A. Design Problems

Due to the high cost of computing power of years gone by, FEA has a history of being used to solve complex and cost crit-ical problems. Classical methods alone usually cannot provide adequate information to determine the safe working limits of a major civil engineering construction or an Automobile or a Nuclear reactor failed catastrophically the economic and social costs would be unacceptably high.

In recent years, FEA has been used almost universally to solve structural engineering problems. One discipline that has relied heavily on this technology is the Automotive and Aerospace industry. Due to the need to meet the extreme demands for faster, stronger, efficient and light weight Au-tomobiles and Aircrafts, manufactures have to rely on the Technique to stay components and the high media coverage that the Industry is exposed to, Automotive and Aircraft companies need to ensure that none of their components fail, that is to cease providing the Service that the design intended.

FEA has been used routinely in high volume production and manufacturing Industries for many years. As to get a product design wrong would be detrimental. For example, if a large manufacturer had to recall one model alone due to a piston design fault. They would end up having to replace up to 10 million pistons. Similarly, if an oil platform Had to shut down due to one of the major components failing (platform Frame, turrets, etc), the cost of lost revenue is far greater than the cost of fixing or replacing the components, not to mention the huge environmental and safety costs that such an incident could occur.

The Philosophy of FEA can be explained with a small example such as measuring the perimeter of a circle. If one needs to evaluate the perimeter of the circle without using the conventional formula, one of the approaches could be to divide the above circle into a number of equal segments. Join the beginning and end points of these segments by a straight line. Since it is very easy to measure the length of a straight line, the length of each line multiplied by the number of lines gives the perimeter of the circle. The same philosophy applies to FEA as well and we shall observe the same as we progress.[4]

Finite element analysis was first developed for use in the aerospace and nuclear industries where the safety of structures is critical. Today, the growth in usage of the method is directly attributable to the rapid advances in computer technology in recent years. As a result commercial finite element packages exist that are capable of solving the most sophisticated prob-lems. Not just in structural analysis, but for a wide range of phenomena such as steady state and dynamic temperature distributions, fluid flow and manufacturing processes such as injection moulding and metal forming.

FEA consists of a computer model of a material or design that is loaded and analysed for specific results. It is used in new product Design, and existing product refinement. A Design Engineer shall be able to verify a proposed design, which is intended to meet the customer specifications prior to manufacturing or construction. Things such as, modifying the design of an existing product or structure in order to qualify the product or structure for a new serviced condition. Can also be accomplished in case of structural failure, FEA may be used to help determine the design modifications to meet the new condition.[4]

IV. CLUTCH

The finite element analysis is the most widely accepted computational tool in engineering analysis. Through solid modelling, the component is described to the computer and this description affords sufficient geometric data for construction of mesh for finite element modelling. Purohit and Sagar (2005-2006) have done the finite element analysis of Al-SiCp composite poppet valve guides and valve seat inserts. Purohit et. al. (2010) have done the linear static analysis of motorcycle piston. [6]

Gao Lian-hua, Jia Xiao-Ping (1993) reported in their ex-periment that the main clutch of heavy vehicles is the basic execution component, which realizes the vehicle to start, shift, move and stop. Separating the main clutch will prevent the transmission device and the engine from being damaged by too heavy load during the violent change of the load over the heavy vehicle.

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A Clutch is a machine member used to connect the driving shaft to a driven shaft, so that the driven shaft may be started or stopped at any time, without stopping the driving shaft. A clutch thus provides an interruptible connection between two rotating shafts. Clutches allow a high inertia load to be started with a small power. Clutches are also used extensively in production machinery of all types.

V. PRESSURE PLATE

Pressure plate is a cast iron plate that provides a pivot fulcrum for the diaphragm spring, a friction surface for the disc and a mounting surface for the drive straps. Pressure plates are round, metallic devices containing springs and fingers, or levers and controlled by the release fork connected to the shifter. All of the clutch components are enclosed in the bell housing of the transmission, between the rear of the engine and the front of the gearbox. The pressure plate pushes the clutch disc against the constantly spinning engine flywheel. The clutch disc, therefore, is either stationary or rotating at the same speed as the flywheel. Friction material, similar to that found on brake pads and brake drums, causes the clutch disc to spin at the same speed as the engine flywheel. It is this friction between clutch disc and flywheel that allows the engine torque to drive the wheels.

There are three major types of pressure plates: (1) The Long style which is used mainly for drag racing.

(2) The Borg Beck which is more robust materials

(3) The diaphragm pressure plate is best suited for street use and is, therefore, the most common type found on later-model automobiles. It contains a single Bellville-style spring that applies a more even load from clutch plate to flywheel. Because the single-spring diaphragm is more effective over-center, there is also less effort needed by the driver to hold the clutch pedal in the depressed position at a stop. In the present design a diaphragm pressure plate has been selected.

VI. RESULTS

A. Static Analysis

Material	Young's Modulus (N/mm^2)	Poisons Ratio	Density (Ton/mm^3)
EN-15 Steel	2.0e5	0.29	7.89e-9

TABLE I. PROPERTIES OF CLUTCH PLATE MATERIALS

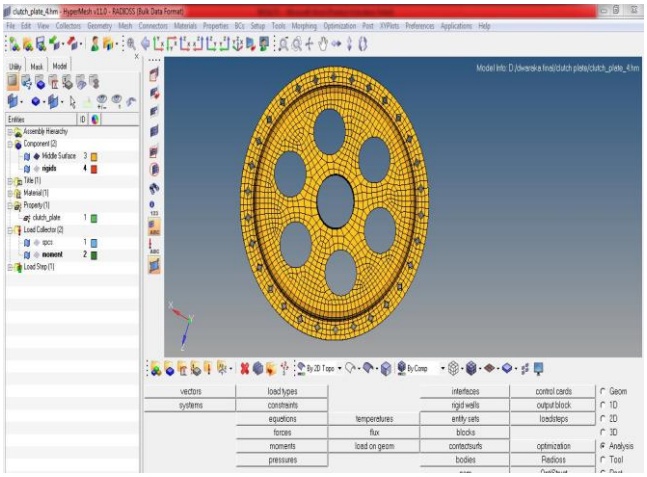

Fig. 2. Hyper mesh meshed drawing of clutch plate

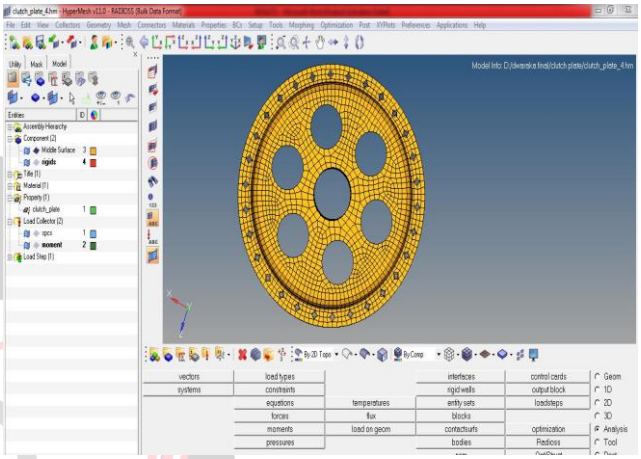

Fig. 3. Hyper mesh meshed drawing of clutch plate side view

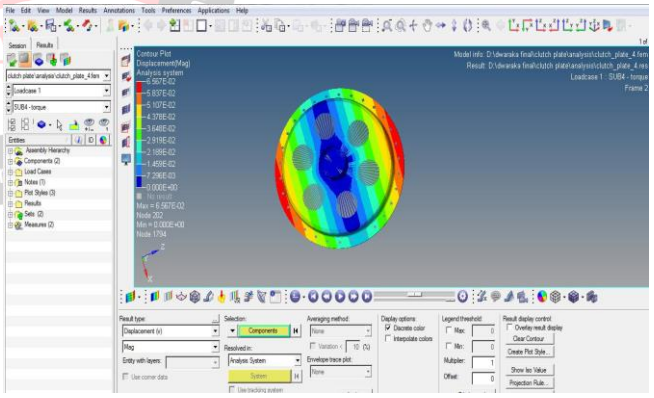

Fig. 4. Maximum deformation (pressure plate) is 0.065mm

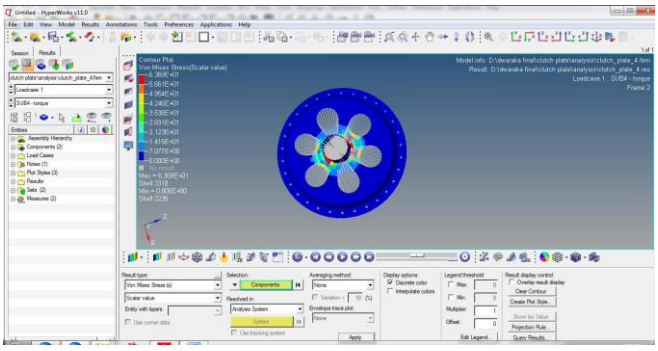

Fig. 5. Maximum von mises stress (pressure plate) is N

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63.69

VII. CONCLUSION

Maximum deformation in mm (pressure plate) after analyzing the materials, we found out von misses stress in MPa (overall component) that the suitability of EN GJS-400-15 steel for the production of clutch plate is better than Grey Cast Iron (FG300). The Stress of En 15 steel is 63.69 MPa, whereas the stress of FG300 is 120 MPa, so the life of the material should be high. Stress on the pressure plate is reduced to 56.31 Mpa.

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