A Review on: Design and Analysis of Clutch and its Subordinate Parts using CAD

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Abstract—Clutch is an important part in the transmission system of the automobiles and transfers power to the driven shaft smoothly. The conventional designing carried various flaws and was difficult to conceptualize from 2D drawings. But the use of solid modelling techniques made it very much simpler for the designer and the analysis software's are used to analyze the parts without actually fabricating the product which indirectly saves money and material as well as time improving the productivity of the working. We can analyze various products precisely in the software and improve the design as per the requirement and values obtained. This paper studies the work done by the various researchers on the clutches and its sub parts like friction plate, diaphragm, etc. and also gives the brief knowledge about the use of computer aided applications on the clutches, types of possible analysis and its wide scope in the design improvisation.

Keywords: Analysis, ANSYS, CAD, Clutch, Clutch Plate, Design, Friction plate

I. INTRODUCTION

Clutch is a transmission device used to transmit the engine power from source to drive shaft. Clutch is also used to employ and misemploy the flywheel to the driven shaft. It is primarily used for the smooth transfer of torque to the driven shaft. While the engine is running we may need the idle driven shaft this can be possible with the help of Clutch. While engaging thee gears we need to disengage the clutch then select the gear and again smoothly engaging the clutch. The clutch assembly consist of various parts such as housing clutch, wheel clutch, clutch Hub, Pressure plate, Clutch Plate, Friction Plate, etc. there are different types of clutches used in the automobile transmission. Based on the design it can be divided into following types.

(1) Single plate type clutch
(2) Multi-plate type clutch
(3) Centrifugal type clutch
(4) Cone type clutch

Nowadays design of the part is done on the solid modelling software's like CATIA, PRO-E, AUTOCAD, etc and the structural analysis is also done on the software like ANSYS, ABAQUS, etc a solid model of multi plate friction plate is designed and its structural analysis carried out on the ANSYS workbench considering Kevlar and cork as the friction material. From the ANSYS simulation best material for the friction material can be chosen and also the capacity of different composite can also calculated [1].

A reliable and efficient analysis can also be done on mechanical clutches using computer modelling. Also, stress analysis and reduction of forces in single plate type of clutch of automobile can be done with the help of software approaches. Based on such methodology an efficient and reliable design of clutch can be found [2].

Design and static structural analysis of the friction clutch plate can be done on CATIA and ANSYS. Also, the von-mises or equivalent stress, strain and the total part deformation can also be evaluated for the different material of friction plate and the obtained data can be analyzed accordingly [3].

A model of single plate clutch is also created in CATIA V5 and imported for analysis in ANSYS workbench. The static structural analysis shows the results such as stresses and maximum deformation. The material for the analysis used is FTL097. The material used is composite material and have high coefficient of friction up to 0.38±0.05. From the software analysis they were able to find the safety and working limits of the material [4].

The multi plate wet type clutch assembly is designed and CAD model is designed of the clutch to explain the working of clutch, and also the suitable material is suggested. The design made is in the way of improving the transmission efficiency. Also, the analyzed error solution is given [5].

Single Plate clutch of Toyota KUN 25 is analyzed in ANSYS workbench and its stresses and deformations are calculated by doing structural analysis using finite element analysis. Depending on the various materials the values of stress and deformation are obtained. [6]

Design and structural analysis of diaphragm of single plate clutch is done. For force motors vehicle, design is done in the software CATIA and structural analysis in HYPERMESH. Stress distribution is found in the analysis and the safety of design is checked while comparing with the theoretical result. [7]

The design of friction clutch assembly can also be done in the solid works software. The clutch plate, pressure plate and diaphragm spring is designed in solid works. Structural Analysis is done on the ANSYS software and the continuous optimization is done on the design until the safe design obtained and values considered for these are stress, deformation and factor of safety. [8]

As the clutch assembly undergoes rapid wear and tear. The design is improved by using docking and the afterwards analysis is done on the clutch as well as flywheel and various parameters such as equivalent stress, deformation and structural error is found out using ANSYS software.[9]

The design of single plate clutch from the theoretical calculation is done and the analysis of the clutch for materials (cast iron, copper and alloy steel) the strain, stresses are found and the better material is suggested. i.e. cast iron. All these work is done in the SolidWorks. [10]

The static structural analysis of clutch plate in SolidWorks and the analysis in the ANSYS 16.0 for the values such as equivalent stresses, deformations and strains. The values are used to improve the life of clutch plate. Also the failure frequencies are found. [11]

To obtain the optimal weight and avoid failures and reduce the cost also we can use the design and analysis software. The design of friction clutch plate for optimum results designed in PRO-E and analyzed in the ANSYS. [12]

The following fig. 1 shows the assembly of the clutch and also its various parts. The multi plate type wet clutch components are shown below. Also the fig. 2 shows the schematic of the clutch for the understanding purpose.

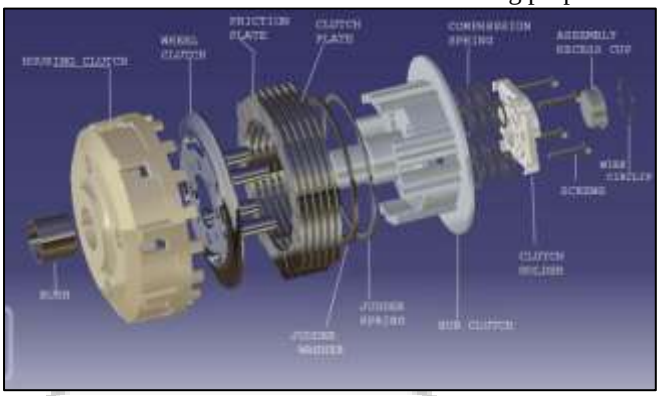

Fig. 1: Assembly of Multi Plate type wet clutch [5]

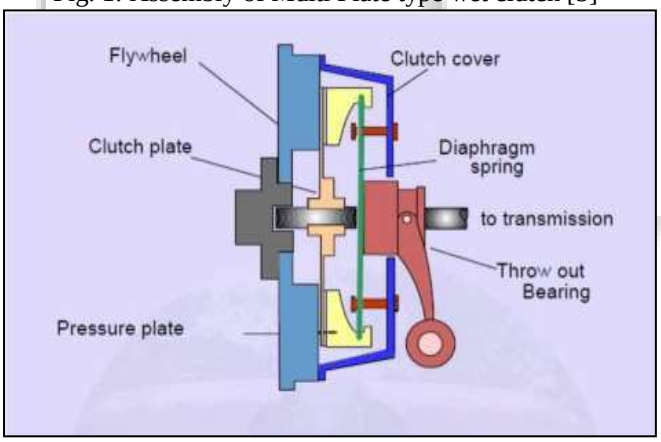

Fig. 2: Schematic of the Single plate type clutch [11]

II. Components of the Clutch Assembly

The main components which are designed and analyzed by the most of the researchers are listed below and the various aspects about it are discussed.

- Clutch Plate
- Friction plate
- Diaphragm
- Flywheel
- Pressure Plate

A. Clutch Plate

Clutch plate is the disc present in the clutch assembly in between flywheel and pressure plate when the clutch is applied the clutch plate comes in contact with the flywheel and the power is transmitted to the driven shaft. It consists of Clutch Hub and Friction Lining the material generally used for the friction lining is ceramic material. But considering the design aspect the clutch is designed considering the parameters such as torque needs to be transmitted, RPM, Stresses to bear, etc. The calculations can be done using mathematical relations. After the values are obtained for the design in conventional designing a drafted design was used to made and then their fabrication is done. After that for analysis various tests are done to check the working ability of the part. Which is very time consuming process instead the use of solid modelling techniques made it very much simpler and efficient. Also, various type of materials are analyzed in the analysis software's. The Following fig. 3 shows general clutch plate.

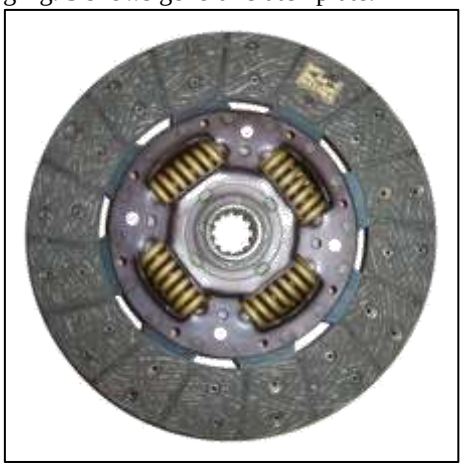

Fig. 3: Clutch Plate

B. Friction Plate

Friction plate are the plates mounted on the either on the clutch plate as friction lining or in multi plate wet type clutch various friction plates used in between the clutch plate. In a wet type clutch the friction plates are worked in the oil bath which improves the life of it. Wet clutches mostly use composite type of material. The common Material used is cork as it's availability and inexpensiveness. While some other materials are also tested for the same design by the researchers and shows the better resistance than cork like sintered bronze, carbon fiber, asbestos, Kevlar 49, etc. The following fig. 4 shows the wet type multi plate friction plate.

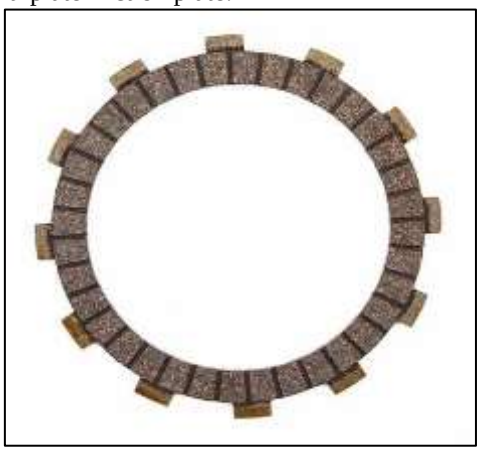

Fig. 4: Friction clutch plate

C. Diaphragm

The diaphragm is a type of disc which provides the pressure force to the engagement of clutch. The general view of

diaphragm is shown in the figure 5. The Diaphragm spring work as a clamping spring and like the release lever as well. When we apply the pedal or push the lever the clutch gets disengaged because the diaphragm spring releases the clamping force and after the pedal is released it again restores the clamping force in spring and engages the clutch smoothly.

Fig. 5: Diaphragm

III. Design and Analysis of Clutches

Solid modelling involves the designing of the part from theoretical dimension and directly 3D model can be seen in the solid modelling. No drafted view are required, it is easy for understanding purpose and interactive as well we can make changes according to need anytime on the software. The common software used for solid modelling design are CATIA, SOLIDWORKS, PRO-E, etc. we can make solid model from theoretical design data and directly have the actual lookalike model ready, no need of any fabrication is there. The ease with the interface and various benefits such as cost saving and time reduction in design process made the solid modelling popular. The process flowchart for the designing and analysis is shown below in Fig 6.

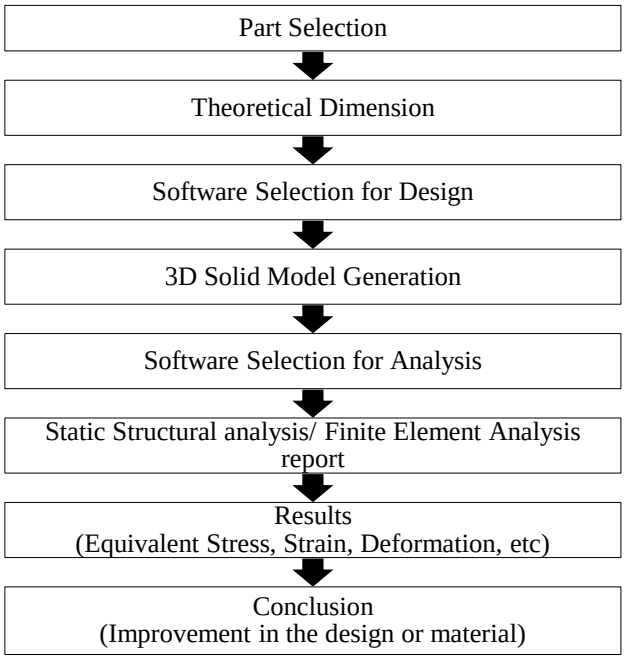

Fig. 6: Flowchart for Design and Analysis of the product

Analysis is a main inspection aspect of the product. It checks the boundary parameters of the product and provides with the ultimate failure values of the product such as equivalent stress, deformation, strain, etc. The common analysis interfaces used by the researchers are ANSYS, SOLIDWORKS, CATIA, etc. As the design and analysis of clutches requires the various materials under consideration and the designing is also complicated. So, they have chosen the particular software according to need. As the interfaces covers wide varieties of materials and also the common type of analysis which are useful can be done in that. The analysis which are elaborative for the working parameters of the product are

(1) Structural Analysis
(2) Finite Element Analysis

The overall review of the research and work done is shown in the following figures. The following table shows the work done by the researchers and elaborating the designed and analyzed parts with respect to material used and also the software used:

Researcher	Designed part	Material	Software used for Design	Software used for Analysis
Nishant Dhengre at. el (2018)	Friction Plate (CT100) Multi-plate type clutch	Cork, Kevlar Fiber	SolidWorks	FEA
Vishal Deshbhrtar at. El (2013)	Clutch Plate (TATA 475) Single plate Friction Clutch	Steel	PRO-E	ANSYS
S. Gouse Seema begum at.el (2015)	Friction Clutch plate (Passion Plus) Multi-Plate type Clutch	Grey C.I., Kevlar 49	CATIA V5	ANSYS
Ravikiran Tate at. El (2015)	Clutch Base Plate, Friction Liner Plate (Automatic Single Plate Clutch)	FTL095	CATIA V5	ANSYS
Rahul Raikwar at. el (2015)	Wet type multi plate clutch assembly	Steel, Carbon Fibre, Asbestos, cork, Aramide Fiber	CATIA	-
Sunny narayan at. el (2018)	Clutch Plate (TOYOTA KUN 25) Single plate type clutch	Asbestos, Sintered Metal, Ceramic, composite	CATIA V5	(FEA) ANSYS
Abhijit ruphar at. el	Diaphragm Spring (Force	Steel	CATIA V5	HYPERMESH

(2016)	Motor) Single plate Dry clutch			
Rajesh purohit at. el (2014)	Clutch Plate, Pressure Plate, Diaphragm spring	Asbestos, Cast Iron GS 70-02, Spring Steel	SolidWorks	ANSYS
T. Vijayraj at. el (2017)	Single plate dry clutch, flywheel, clutch assembly	Ceramic Alloy, Mild steel, mild steel	-	ANSYS
May thin gyan at. el (2014)	Single Plate Clutch, Friction Plate	Cast Iron, Alloy steel, Copper	SolidWorks	SolidWorks
Kunchala brahmaich at. el (2018)	Clutch friction plate	Structural steel, Stainless steel	SolidWorks	ANSYS
N.A. Barve at. el (2017)	Clutch base plate, pressure plate, friction material	Structural steel, Grey C.I. Kevlar Aramid fibre	PRO-E	FEA ANSYS

Table 1: Overview of work done on the Designing and Analysis of the Clutch and its Assembly Parts

IV. RESULTS

Part Name	Material	Equivalent Stress	Strain	Deformation
Friction Clutch Plate[1]	Cork	4.4380e5 Pa (under 58N load)	-	-
	Kevlar	6.2122e5 Pa (under 58N load)	-	-
Single plate Friction Clutch[2]	Steel	1.108e3 Pa	-	0.743e-8 m
Friction Clutch Plate[3]	Grey C.I.	22868 Pa	1.1723 e-8	3.755 e-10 m
	Kevlar 49	18054 Pa	9.2547 e-8	2.9645 e-10 m
Clutch Base[4]	FTL095	4.10 N/mm^2	-	-
Liner [4]	FTL095	0.07979 N/mm^2	-	1.7 x 10-10
Clutch Plate[6]	Asbestos Lining	271.53 MPa	-	0.14507 mm
Clutch Plate[6]	Sintered Metal	271.54 MPa	-	0.14515 mm
Clutch Plate[6]	Cermet	273.02 MPa	-	0.14265 mm
Single Plate Clutch[10]	Cast Iron	275354.8 N/m^2	2.67e-5	1.057e-5 mm
Friction Plate[10]	Alloy steel	279555.5 N/m^2	8.526e-7	3.360e-6 mm
Friction Plate[10]	Copper	324899.1 N/m^2	1.860e-6	7.048e-6 mm

Table 2: Result Value Obtained after the analysis

The results obtained by the researchers and the parameters such as stress, strain and deformation are shown in below table. We can determine the best material and analyze the capacity of the part to work up to which limit and then improvising the design for the better performance. Also the values obtained are ideal and can be considered while improving the design. Some of the researchers have done static structural analysis, modal analysis and some has done FEA. The overall data shows the result obtained for the various materials.

V. CONCLUSION

- The design and analysis process makes the idea clear about the parameters which will affect the part performance and making the improvisation in design while making Single plate clutch as well as multi plate clutches.
- The material which will provide better life for the friction clutch plate is also chosen from the above study and also the values of the materials are taken into consideration while designing friction Clutch plate.
- Also for the Single type clutch plate the friction lining material is chosen from the deformation value as the wear and tear affect the lifespan of clutch and burnout of clutches is reduced. A suitable material selection will improve the product quality.
- For the analysis of Diaphragm spring FEA is preferred as the values obtained by FEA of stress and deflection are more accurate than that of structural analysis.
- The data obtained from the analysis is used to specify whether the design is safe or not. No physical testing is required all processes can be done easily and the design and analysis of clutch is done accurately.
- The mostly used interface for the analysis is ANSYS workbench and for designing CATIA is used for Clutches.

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