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Design and Analysis of Friction Clutch Plate using Ansys

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Abstract— *Clutch is one of the essential components in automobiles. It is located between the engine and the gear box. The main function of the clutch is to initiate the motion or increase the velocity of the vehicle by transferring kinetic energy from the flywheel. The present paper deals with the designing and analysis of friction clutch plate. Design has done by using CATIA V5 software and static structural analysis carried by using ANSYS. Finally the plots for equivalent stress, strains and total deformation were obtained for different friction materials for friction clutch plat, Uniform wear theory were used for the analysis.*

Keywords— ANSYS, Clutch, friction plate, gray cast iron, kevlar49.

I. INTRODUCTION

Clutches are designed to transfer maximum torque with minimum heat generation. In order to stop the vehicle without stopping the engine, the wheels should be disconnected from the engine, which facilitates through clutch. It is a mechanism for transmitting rotation which can be engaged and disengaged.

It also involved for disconnection between the engine from the transmission to change the gear through clutch, which takes up the drive smoothly, not only that it also absorb powerful engine power pulsations, so that they are not transmitted through the driveline, which accomplishes these tasks through careful design and the use of both static and sliding or kinetic friction.

The friction materials which are suitable for friction clutch plate are Gray cast iron, Cork, SF-BU, Kevlar49, SF001, Sintered iron Aluminum 6061, Steel, pressed asbestos, Bronze etc.

Mainly there are two types of clutches, one is single plate clutch which is used for small duty vehicles and the other is multi plate clutch, which has number of friction plates and steel plate's assembly used for heavy duty vehicles.

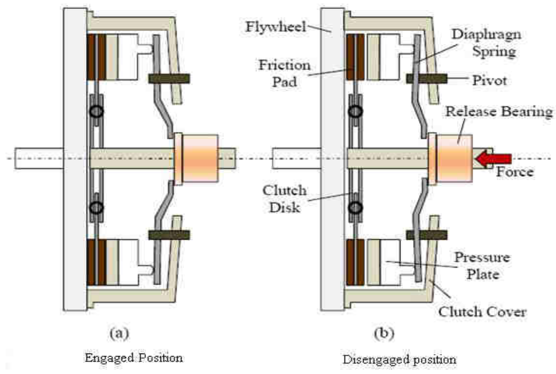

Fig 1: Engagement and disengagement of clutch plate

Fig 1(a) shows the engagement position of clutch plates,during this the clutch pedal is engaged with flywheel which transmit power from the engine to the clutch and it is transmitted towards the transmission. Fig(b) shows the disengagement of clutch plates, which does not transmit power towards the transmision.

The past literature revealed that Jaykishore and Lava kumar [2] and Ganesh Rautt et.al [3] are proposed different materials for a multi plates and structural analysis of a multi plate clutch plates.Ganesh Raut et.al [1] has focused on comparision of diferent materials for friction surfaces by keeping the alumnium as base material and analysis of multi plate clutch.P.Naga Karna and Tippa Bhimasankara Rao [3] has performed the static analysis on Friction clutch plate by using Finite element analysis the results of stress distribution and temperature distribution has been carried out. B.c Joseph and M.Vasundara [4] and G.Pawar et.al [6] were demonstrated the total deformation of clutch plate for different materials to find the better lining material and structural analysis of multi plate clutch using ANSYS. Shaik Mohammad Ali and N.Amaranageswara[11] has studied about different materials for friction clutch plate and find the stress values for structural analysis and temperature values for thermal analysis of positive multiple Friction plate using FEA. Rajesh purohit et.al[13] has explained about the design and analysis of automotive clutch assembly, the plots for equivalent stress,total deformation, and factor of safety has obtained

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and the design was continuously optimised till a safe design was obtained.

In this paper, the design of friction clutch plate was done by using CATIA V5 R20 software and structural analysis was done by using ANSYS, by selecting the friction materials as Kevlar49 and gray cast iron. Finally comparing the stresses, strains and total deformation are obtained, the best material for friction clutch plate has been found.

II. NOMENCLATURE AND SELECTION OF MATERIALS

2.1 Nomenclature

T Torque, Nm
n Speed, rpm
r_1,r_2 inner and outer radius of friction face, mm
R mean radius of friction surface, mm
n_1,n_2 no.of discs on driving and driven shafts
W Total operating force, N
p Intensity of pressure, N/mm^2
μ Coefficient of friction

2.2 Selection of materials

The following are the different types of materials used for clutch plate

2.2a. Gray cast iron as Friction material

Gray iron, or grey cast iron, is a type of cast iron that has a graphitic microstructure. It is named after the gray color of the fracture it forms, which is due to the presence of graphite. It is the most common cast iron and the most widely used cast material based on weight.

The clutch disc is generally made from grey cast iron (Afferents 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 materials 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). In this project, BS200 or ASTM G2500 grade grey cast iron is selected as the material for the commercial clutch disc.

2.2b. Kevlar 49 as friction material

Kevlar was introduced by DuPont in the 1970s. It was the first organic fiber with sufficient tensile strength and modulus to be used in advanced composites. Originally developed as a replacement for steel in radial tires, Kevlar is now used in a wide range of applications.

Kevlar 49 is the registered trademark for a paraaramid synthetic fiber, comparable to other aramids such as Nomex and Technora. Developed by Stephanie K. wolek at DuPont in 1965, this high strength material was used commercially for the first time in the early 70s as are placement for steel in racing tires. Typically spun into ropes or fabric sheets that could be used as such or as an ingredient in composite materials. Since it has a high strength-to-weight ratio Kevlar has found many applications, ranging from bicycle tires to body armor. By this measure it is about 5 times stronger than steel on an equivalent weight basis. As it can withstand high impact it is also used to make modern drum lining. It is suitable for mooring lines when used as a woven material, for underwater applications and for possible replacement as lining material.

S.No.	Material	Density (Kg/m^3)	Poisson's ratio	Tensile strength (Mpa)	Coefficient of Friction
1	Gray Cast iron	7200	0.29	220	0.28
2	Kelvar 49	1439.35	0.36	124	0.5

Table 1: Material properties for Gray cast iron and Kevlar 49

III. MATHEMATICAL CALCULATION AND METHODOLOGY

Specifications of the passion plus

Torque (T)	=	7.95	N-m
Speed (n)	=	5000	Rpm
Inner radius of friction face (r_1)	=	36.13	Mm
Outer radius of friction face (r_2)	=	54.2	Mm
Mean radius of friction surface ($R=(r_1 + r_2)/2$)	=	45	mm
No. of discs on driving shaft (n_1)	=	5	
No. of discs on driven shaft (n_2)	=	4	
No. of pairs of contacting surfaces ($n=n_1 + n_2-1$)	=	8	
Total operating force (W)	=	44.167	N
Intensity of Pressure at radius r (p)	=	0.011	N/mm^2

3.1. Gray cast iron friction material

Required operating force:

$T = n*\mu*w*R$

$7.95= 8\times0.28\times w\times0.045$

$w = 7.95 \div (8\times0.28\times0.045)$

$w = 78.869N$

Average operating pressure:

$w = (2\times\pi\times P\times r2) \times (r1-r2)$

$44.167 = (2\times\pi\times p\times 36.13) \times (54.2-36.13)$

P= 0.019 MPa.

3.2. Kevlar 49 friction material

Required operating force:

$T = n*\mu*w*R$

$7.95 = 8\times0.36\times w\times0.045$

$w = 7.95 \div (8\times0.36\times0.045)$

$w = 61.343$ N

Average operating pressure:

$w = (2\times\pi\times P\times r2) \times (r1-r2)$

$61.43 = (2\times\pi\times P\times 36.13) \times (54.2-36.13)$

P = 0.015Mpa

IV. STRUCTURAL ANALYSIS OF FRICTION PLATE

The multi plate clutch has modeled in CATIA V5 R20 software and imported in ANSYS Workbench 14.5. The structural analysis has been carried out for both Gray cast iron and Kevlar 49 friction material clutch plate. The results of using both friction materials have been compared based on the total deformation of the friction plate.

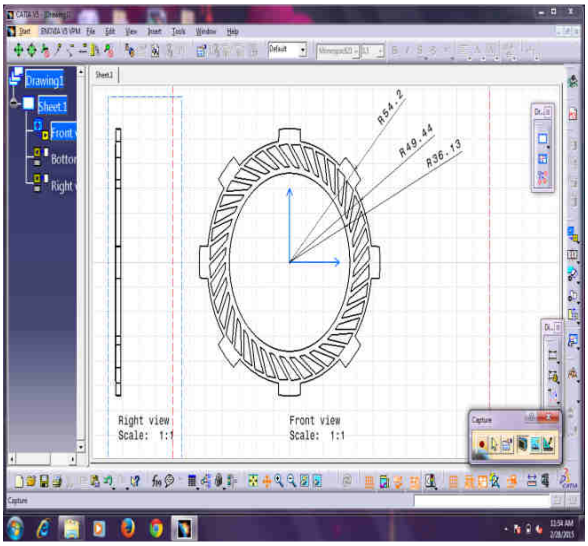

Fig 2: 2-D model of friction plate

4.1 Friction material as gray cast iron

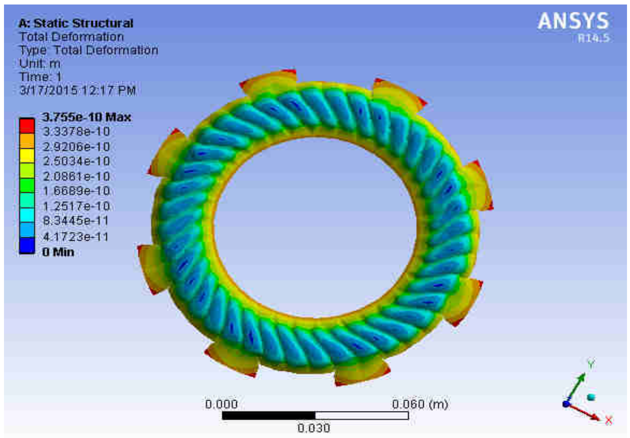

Fig 3: Total deformation

The total deformation for gray cast iron friction plate occurs at the edges and it is about$3.755e^{-10}$m, which is as shown in the figure 3.

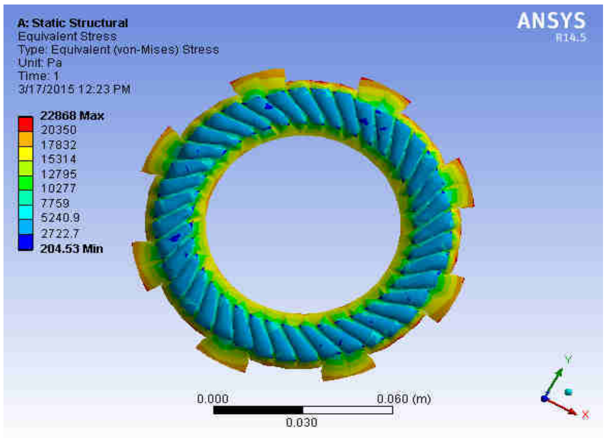

Fig 4: Equivalent (vonmises) stress

The figure 4. shows the vonmises stress for gray cast iron friction clutch plate, the maximum stress will occur across the edges of the friction plate.

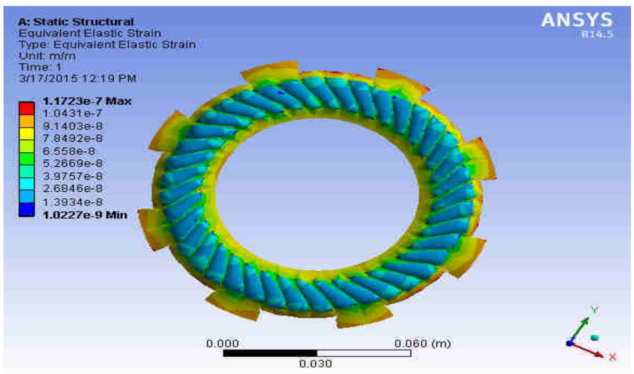

Fig 5: Equivalent elastic strain

For gray cast iron as friction material for friction clutch plate, the equivalent elastic strain is distributed along the edges of the friction clutch plate as shown in fig 5.

4.2 Friction material as Kevlar 49

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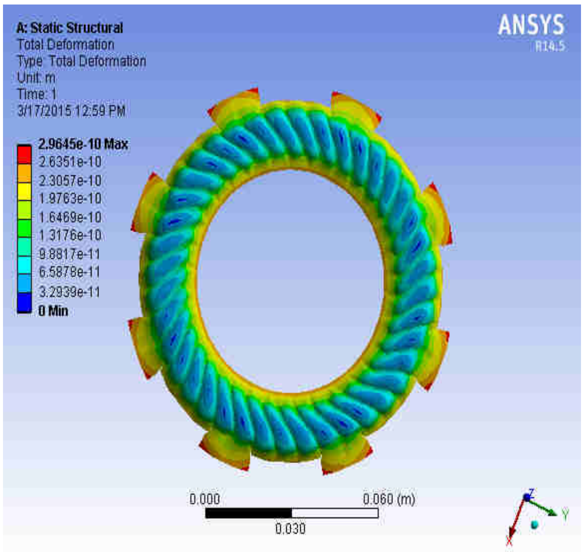

Fig 6: Total deformation

The total deformation for Kevlar49 friction plate occurs at the edges and it is about $2.9645e^{-10}$ m, which is as shown in the above figure 6.

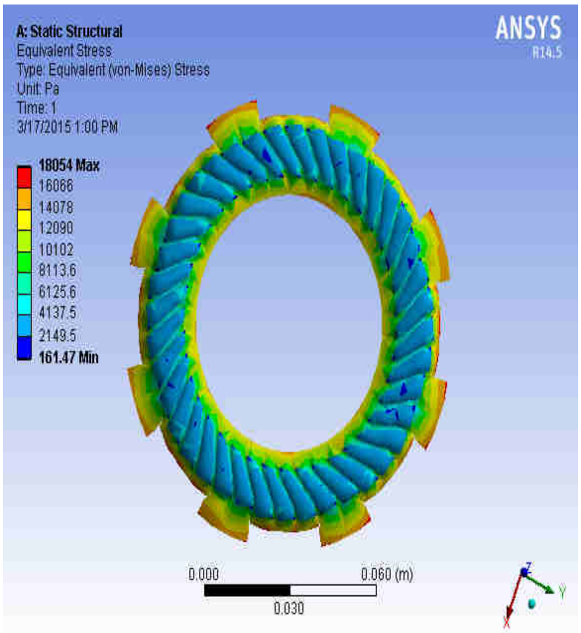

Fig 7: Equivalent (von mises) stress

The above figure shows the von mises stress for Kevlar49 friction clutch plate, the maximum stress will occur across the edges of the friction plate.

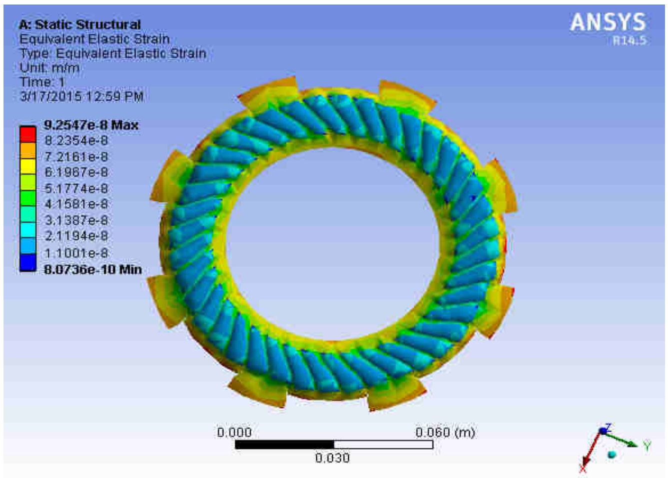

Fig 8: Equivalent elastic strain

For Kevlar49 as friction material for friction clutch plate, the equivalent elastic strain is distributed along the edges of the friction clutch plate as shown in fig 8.

Material	Vonmisses Stress (Pas.)	Vonmises Strain	Total Deformation (m)
Gray cast iron	22868	1.1723 e^{-8}	3.755 e^{-10}
Kelvar 49	8054	9.2547 e^{-8}	2.9645 e^{-10}

Table 2: Structural analysis results

V. CONCLUSION

In this paper, a friction plate has been designed by using CATIA V5 R20 software and theoretical calculations and also structural analysis has done by using ANSYS Workbench 14.5.

The materials gray cast iron and Kevlar 49 has been selected for friction plate and structural analysis has been done to find the total deformation, equivalent (von mises) stress and equivalent elastic strain. By comparing the results it is clear that Kevlar 49 has less deformation than Gray cast iron. Thus the material Kevlar 49 is more advantageous than Gray cast iron.

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