

Structural Analysis of Multiplate Clutch using ANSYS

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ABSTRACT

Multiplate clutch is one of the important parts in the power transmission systems. Good design of clutch provides better system performance. Multiplate clutch is widely used in racing cars and heavy duty vehicles which have space limitations and require high torque transmission. In this paper a multiplate clutch has been designed by using empirical formulae. The multiplate clutch has been modeled using SOLIDWORKS 2013 and imported in ANSYS workbench for performing structural analysis. The Von Mises stress has been determined by varying the friction surfaces material-SFBU and Kevlar 49. The SFBU friction material and Kevlar 49 friction material are compared based on the total deformation of the clutch plate to find the better lining material.

Keywords

SFBU, KEVLAR 49, Stress, strain, Von Mises stress, Deformation

1. INTRODUCTION

Clutch is a mechanical device, which is used to engage or disengage the source of power from the rest of the power transmission system at the operator's will. The clutch can connect or disconnect the driving shaft from the driven shaft when necessary. An automotive clutch can permit the engine to run without stopping the vehicle. This is desirable when the vehicle is to be started or stopped, or when gear shifts are needed. Clutch is a mechanism for transmitting rotary motion, when needed. The clutch connects the two shafts so that they can either be coupled together and spun at the same speed (engaged), or be decoupled and spun at different speeds (disengaged). Depending upon the orientation, speed, material, torque required and finally the use of the whole machine, different kinds of clutches are employed. The clutch may be described as a mechanism in itself, which employs different configuration. The friction clutch is an important component of any automotive vehicle. It provides the connection between engine and transmission system which transfer power, in the form of torque, from engine to the gearbox. When vehicle is started from idle state, clutch is engaged to transmit torque to the transmission; and when vehicle is in motion clutch is first disengaged off the driving shaft to allow for gear change and then again engaged for smooth power transfer to the vehicle parts. Generally there are two types of clutches based on the

type of contact :

- Positive clutch
- Friction clutch

Multi plate clutch is classified under the category of friction clutch. Multi plate clutch is an extension of the single plate clutch where the number of friction plates and metal plates are increased. This increase in the number of friction surfaces obviously increases the torque transmission capacity of the clutch, size remaining the same. Alternatively, the overall clutch diameter is reduced for the same torque transmission as in a single clutch plate. Hence this type of clutch is, used in heavy transport vehicles and racing cars where high a torque is required. Besides, this finds application in scooters and motorbikes, where available space is limited.

1.1 Desirable properties for clutch plate lining:

- The materials in contact must have a high coefficient of friction.
- The materials in contact must high resistance to wear effects, such as scoring, galling, and ablation.
- The coefficient of friction should be constant over a specified range of temperatures and pressures. The material must be resistant to environmental conditions such as moisture, dust and pressure.
- The material should possess good thermal properties, high specific heat capacity, good thermal conductivity and capable of withstanding high temperatures and contact pressures.
- The material should possess high shear strength to transfer torque.

2. MATERIALS USED FOR CLUTCH PLATE

2.1 Friction material SF-BU

SF-BU is a high performance material with high friction coefficient. It is a non-metallic composite containing a higher percentage of aramid fibre. It can be considered as a possible alternative to sintered metallic materials and has many advantages. It can withstand high energy inputs, and is suitable for both dry and wet applications. It is not abrasive against the counter material, is silent in operation, and can withstand high pressures. The wear rate is very low even at high temperatures, and can be made available in thicknesses from 0.6mm to 5mm. Applications: heavy vehicle clutches, clutch buttons, trucks clutches, friction gaskets, vehicle clutches.

2.2 Kevlar 49 as friction material

Kevlar 49 is the registered trademark for a para-aramid synthetic fiber, comparable to other aramids such as Nomex and Technora. Developed by Stephanie Kwolek at DuPont in 1965, this high strength material was used commercially for the first time in the early 70s as a replacement for steel in racing tyres. 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 tyres 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.

Table 1. Materials used in multi plate clutch

Sl No	Material	Density (Kg/m ³)	Poisson's ratio
1	SFBU	1250	0.5
2	Kevlar49	1439.35	0.36
Material	Tensile strength (MPa)	Coefficient of friction	
SFBU	70	0.5	
Kevlar49	124	0.35	

3. SPECIFICATIONS OF CLUTCH PLATE

Torque = 127.53 Nm at speed N = 1000 rpm

r₁ = inner radius of friction face

r₂ = outer radius of friction face

r₁ = 69mm and r₂ = 50 mm

n = no of pairs of contact surfaces.

n = n₁ + n₂ - 1

Where n₁ = no of disc on driving shaft

n₂ = no of disc on driven shaft

n₁ = 5 and n₂ = 4; n = 8

R = mean radius of friction surfaces.

μ = coefficient of friction.

T = Transmitting torque.

w = Total operating force.

P = Intensity of pressure at radius r (N/mm²).

Calculation of operating force and average operating pressure by using uniform wear theory is as follows:

3.1 For friction material SFBU

$$R = (r_1 + r_2) / 2$$

$$= (69 + 50) / 2$$

$$= 59.5 \text{ mm}$$

$$= 0.0595 \text{ m}$$

Required operating force:

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

$$127.53 = 8 * 0.5 * w * 0.0595$$

$$w = 127.53 \div (8 * 0.5 * 0.0595)$$

$$w = 535.84 \text{ N}$$

Average operating pressure:

$$w = (2 * \pi * P * r_2) * (r_1 - r_2)$$

$$535.84 = (2 * \pi * P * 50) * (69 - 50)$$

$$P = 0.0897 \text{ MPa}$$

3.2 For friction material Kevlar 49

Required operating force:

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

$$127.53 = 8 * 0.35 * w * 0.0595$$

$$w = 127.53 \div (8 * 0.35 * 0.0595)$$

$$w = 765.48 \text{ N}$$

Average operating pressure:

$$w = (2 * \pi * P * r_2) * (r_1 - r_2)$$

$$765.48 = (2 * \pi * P * 50) * (69 - 50)$$

$$P = 0.1282 \text{ MPa}$$

4. STRUCTURAL ANALYSIS OF FRICTION PLATE

The multiplate clutch was modeled in Solidworks 2013 and imported in Ansys Workbench. The structural analysis has been carried out for both SF-BU friction material plate clutch and Kevlar 49 friction material plate clutch. The results of using both SF-BU lining plate clutch and Kevlar 49 lining plate clutch have been compared based on the total deformation of the friction plate.

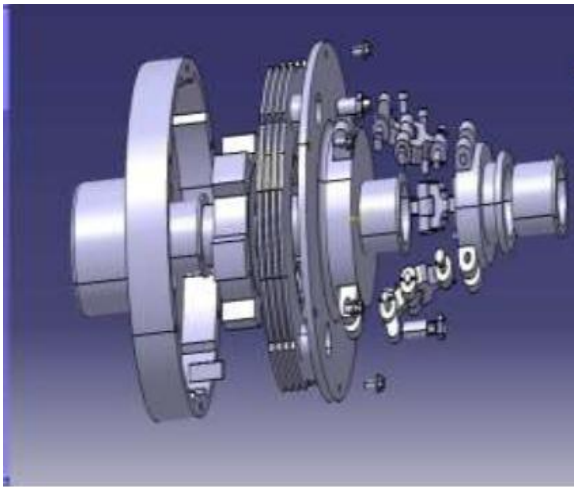


Fig 1: 3D drawing of clutch assembly

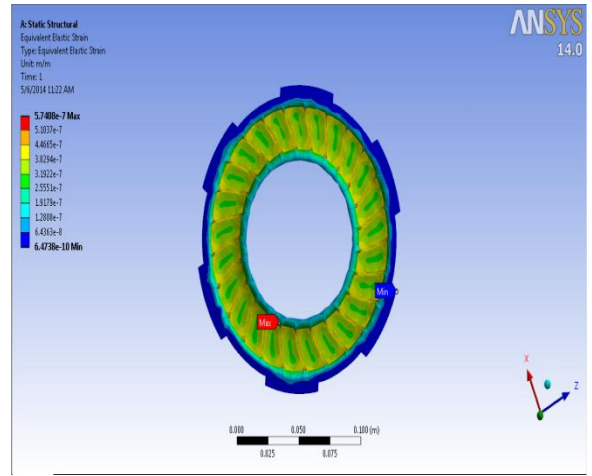


Fig 4: Von-Mises Strain results of friction plate using SF-BU as friction material.

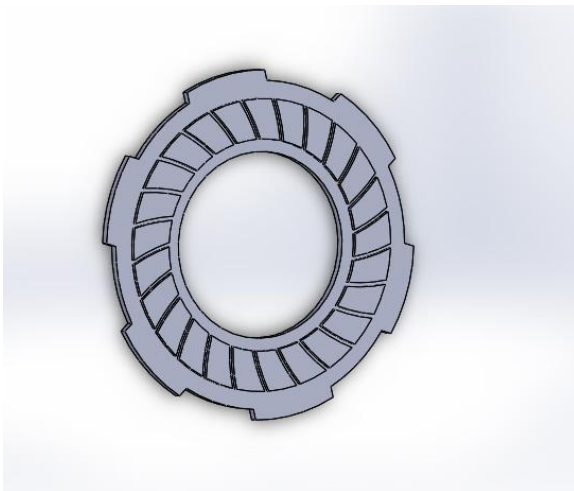


Fig 2: 3D solid model of clutch plate

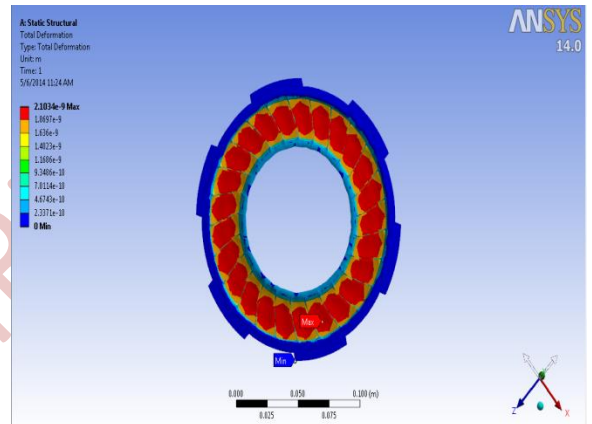


Fig 5: Total deformation of friction plate using SF-BU as friction material

4.1 Friction Material SF-BU

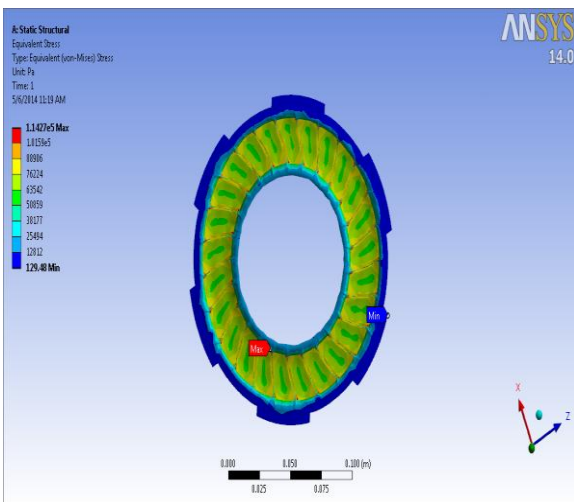


Fig 3: Von-Mises Stress results of friction plate using SF-BU as friction material.

4.2 Friction Material Kevlar 49

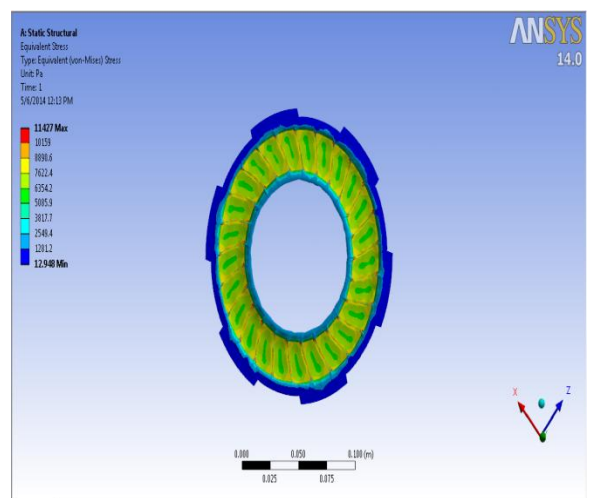


Fig 6: Von-Mises Stress results of friction plate using Kevlar 49 as friction material.

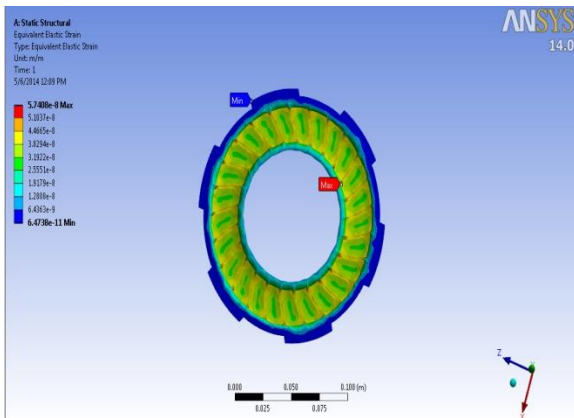


Fig 7: Von-Mises Strain results of friction plate using Kevlar 49 as friction material.

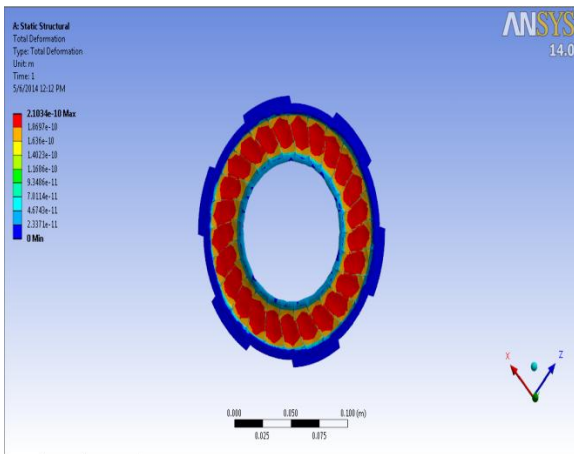


Fig 8: Total deformation of friction plate using Kevlar 49 as friction material

6. REFERENCES

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TABLE 2. Structural analysis results

Material	Von Mises stress (N/mm²)	Von Mises strain	Total Deformation (m)
SFBU	0.1427	5.7e-7	2.109e-9
Kevlar49	0.011427	5.74e-8	2.103e-10

5. CONCLUSION

In this work, a multiplate clutch has been modeled using theoretical calculations and the 3D modeling of the clutch plate has been done using Solidworks 2013. The friction materials SF-BU and Kevlar 49 are used for lining and the structural analysis is performed using Ansys Workbench.