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# Design and Structural Analysis of Single Plate Clutch

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**Abstract:** This paper shows the design of single-plate clutch in automobile. This type of clutch is a dry friction clutch. The design of single plate clutch is drawn by using theoretical calculation results. A 2D drawing of clutch disc is drafted. The comparison result is done for using three materials to define the best material for friction plate. The stress of clutch disc is analyzed to observe the stress, displacement and strain during applying pressure on clutch disc face by using Solid Works software.

**Keywords:** Stress, Pressure, Friction Materials, Solid Works.

## I. INTRODUCTION

In automobile, clutch is a mechanism designed to connect or disconnect the transmission of power from one working part to another. It is located between engine and transmission. It has been seen that internal combustion engine, unlike the steam engine, does not produce high power at low speed. So the engine must be rotating at a speed at which sufficient power is developed, before the drive to the wheels to be established. The clutch used must allow the drive to be taken up smoothly so that the vehicle can be gradually moved away from the stationary position. Once moving, it will be necessary to change gear and so disengagement of the engine or transmission is required. These two duties can be performed by various mechanisms; the friction system is considered.

## II. FRICTION CLUTCH

The friction clutch is an important component of any automobile machine. It is a link between engine and transmission system which conducts power, in form of torque, from engine to the gear assembly. When vehicle is started from standstill, clutch is engaged to transfer torque to the transmission and when vehicle is in motion, clutch is first disengaged of the drive to allow for gear selection and then again engaged smoothly to power the vehicle. Friction clutch is used in manual transmission. It includes flywheel, clutch plate, cutch cover, pressure pate, diaphragm spring and throw out bearing. A diaphragm spring load pushes pressure plate and clutch disc by clutch pedal (see fig 1). The rotation power of engine is transferred from flywheel, which is connected with crankshaft to transmission throw clutch disc, located between flywheel and pressure plate. The friction material of clutch has good shear strength to transferred friction forces to structure. There are three types of friction clutch. They are

1. Disc or plate clutch (single or multiple- clutch)
2. Cone clutch
3. Centrifugal clutch

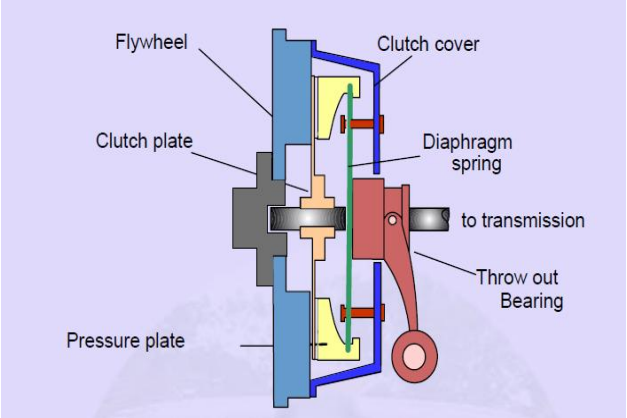


**Figure1. Friction Clutch in Automobile.**

## III OPERATING OF SINGLE PLATE CLUTCH

A single plate clutch consists of a clutch plate whose both sides are faced with a frictional material. It is mounted on the hub which is free to move axially along the spline of the driven shaft. The pressure plate and flywheel rotate with the engine crankshaft or driving shaft. The pressure plate pushes the clutch plate towards the flywheel by a set of strong springs which are arranged radially inside the body. When the clutch is engaged, the power is flows from the engine to the rear wheels through the transmission system and the vehicle moves. When the clutch is disengaged, the power is not transmitted to the rear wheels and the vehicle stops while the engine is still running. The clutch is disengaged when starting the engine, when shifting the gears, when stopping the vehicle and when idling the engine. The clutch permits the gradual taking up of the load. It prevents jerky motion of

the vehicle. The axial pressure exerted by the spring provides a frictional force in the circumferential direction when the relative motion between the driving and driven members tends to takes place. If the torque due to this frictional force exceeds the torque to be transmitted, then no slipping takes place and the power is transmitted from the driving shaft to the driven shaft. Figure 2 shows the main parts of clutch system.

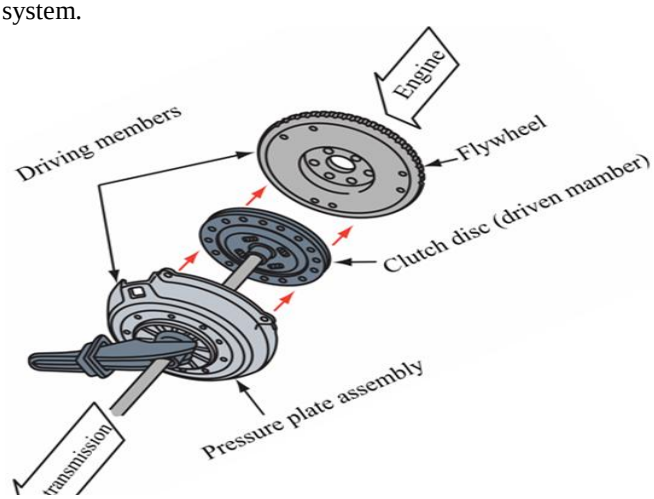


**Figure2. The main parts of clutch system**

## IV. SPECIFICATIONS

Power = 73 hp @ 4700 rpm
Torque = 202.5 N-m @ 2800 rpm
Material used is pressed asbestos on cast iron or steel
μ =0.3
Maximum operating temperature °C = 150-250
Maximum pressure P = 300 kN/m$^2$
Outer $r_o$ and inner $r_i$ radius of friction faces
$r_o$=0.1145 mm, $r_i$= 0.0802 mm
n= numbers of contact surfaces
n= 2
R= mean radius of friction surfaces

For uniform pressure:

$$R = \frac{2}{3}\left[\left(r_o^{\,3} - r_i^{\,3}\right)/\left(r_o^{\,2} - r_i^{\,2}\right)\right] \quad (1)$$

$$= \frac{2}{3}\left[\left(0.1145^3 - 0.0802^3\right)/\left(0.1145^2 - 0.0802^2\right)\right]$$

$$= 0.09836m$$

For uniform wear

$$R = \frac{r_o + r_i}{2}$$

$$= \left[(0.1145 + 0.0802)/2\right] = 0.09735m \quad (2)$$

**A. For considering uniform pressure**

When uniformly distributed pressure is applied over the entire area of friction face,

$$P = \frac{W}{\pi\left(r_o^{\,2} - r_i^{\,2}\right)} \quad (3)$$

Where W= axial thrust with frictional surface

Frictional torque acting on the friction surfaces is included by

$$T = n \times \mu \times W \times R \quad (4)$$

n=number of contact surfaces
μ=coefficient of friction
R=mean radius of friction surfaces
T=135 N-m

$$W = \frac{T}{n \times \mu \times R} \quad (5)$$

$$= \frac{202.5}{2 \times 0.3 \times 0.09735}$$

=3466.8721 N

$$P = \frac{W}{\pi\left(r_o^{\,2} - r_i^{\,2}\right)} \quad (6)$$

$$= \frac{3466.8721}{\pi\left(0.1145^2 - 0.0802^2\right)}$$

=165.24×10^3 N/m^2

**B. For considering uniform axial wear**

Axial force is required to engage the clutch

$$W = 2 \times \pi \times C \times \left(r_o - r_i\right) \quad (7)$$

$$C = P \times r \qquad \text{(C=constant)}$$

The maximum intensity pressure occurs at inner radius ($r_i$) of friction surface

$$C = P_{\max} \times r_i \quad (8)$$

$$C = \frac{W}{2 \times \pi \times \left(r_o - r_i\right)} \quad (9)$$

$$= \frac{3466.8721}{2 \times \pi \times \left(0.1145 - 0.0802\right)}$$

=16086.584 N/m

$$P_{\max} = \frac{C}{r_i}$$

$$= \frac{16086.584}{0.0802}$$

=200.5808×10^3 N/m^2

The minimum intensity pressure occurs at outer radius ($r_o$) of friction surface

$$P_{\min} = \frac{C}{r_o}$$

$$= \frac{16086.584}{0.1145}$$

=140.4942×10^3 N/m^2

Figure3 and 4 shows the single plate clutch and friction plate. The average pressure on the friction surface
Pavg= (Total force on friction surface) / (Cross -sectional area of friction surface)

$$P_{avg} = \frac{W}{\pi\left(r_o^{\,2} - r_i^{\,2}\right)}$$

$$= \frac{3466.872}{\pi \times \left(0.1145^2 - 0.0802^2\right)}$$

=165.2448×10^3 N/m^2

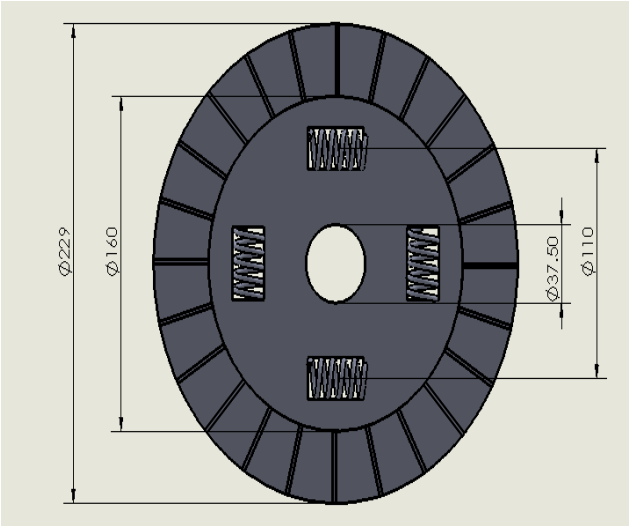


**Figure3. Single Plate Clutch.**

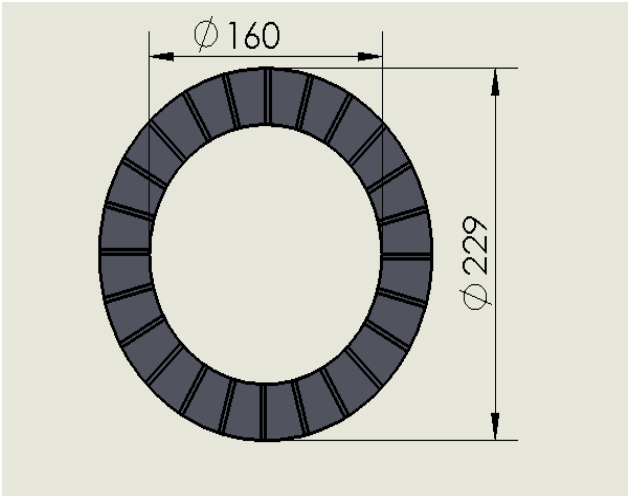


**Figure4. Friction Plate.**

## VI. STRUCTURAL ANALYSIS FOR FRICTION PLATE

- The maximum pressure applying on the friction plate. P=200.2249×10^3 N/m^2.
- The materials properties using in friction plate.

**TABLE 1:** MATERIALS PROPERTIES USED FOR FRICTION PLATE

| Sr. No | Materials | Density (Kg/m^3) | Elastic Modulus (N/m^2) | Poisson's ratio |
|---|---|---|---|---|
| 1 | Cast iron | 7200 | 6.6178e+010 | 0.27 |
| 2 | Alloy steel | 7700 | 2.1e+011 | 0.28 |
| 3 | Copper | 8900 | 1.1e+011 | 0.37 |

**TABLE 2:** RESULTS OF ANALYSIS BY USING SOLID WORKS SOFTWARE

| Material | Vonmises stress N/m^2 | Strain | Displacement (mm) |
|---|---|---|---|
| Cast iron | 275354.8 | 2.670e-005 | 1.057e-005 |
| Alloy steel | 279555.5 | 8.526e-007 | 3.360e-006 |
| Copper | 324899.1 | 1.860e-006 | 7.048e-006 |

**A .Friction material :Cast iron**

The following diagram 5 shws the Vonmises stress of Cast iron using SolidWorks.

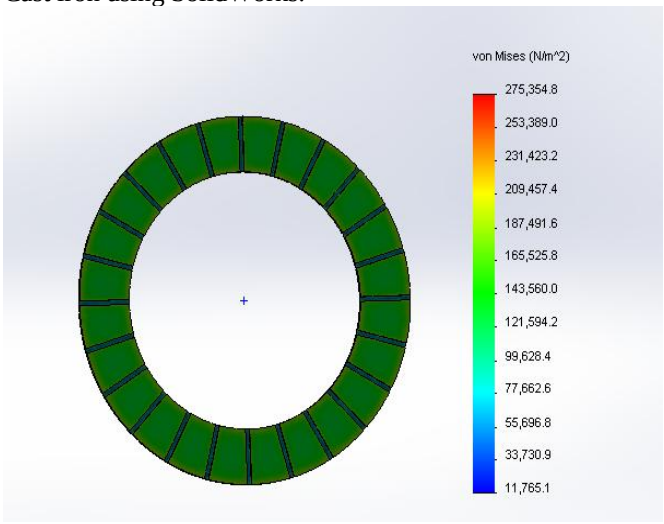


**Figure5. Vonmises stress of Cast iron using SolidWorks.**

**B. Friction material: Alloy steel**

The following fig 6 shows the Vonmises stress of Alloy steel using SolidWorks.

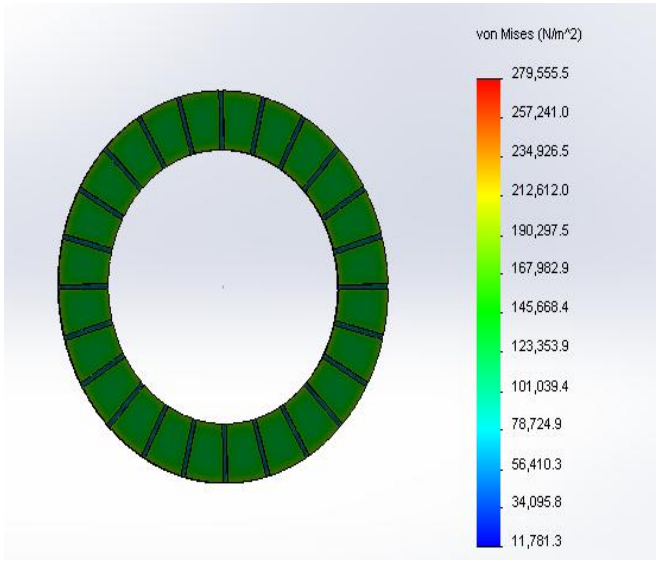


**Figure6. Vonmises stress of Alloy steel using SolidWorks.**

**C. Friction material : Copper**

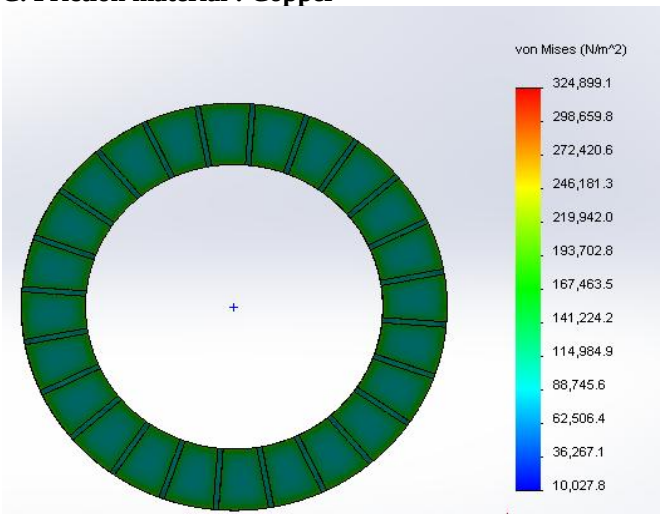


**Figure7. Vonmises stress of Copper using SolidWorks.**

The figure7 shows the Vonmises stress of Copper using SolidWorks.

## VII CONCLUSION

This paper explains the design of single plate clutch 2 drawing is drafted by using theoretical calculations. The strength of friction plate is done by using Solid Works. Friction materials used are cast iron, alloy steel and copper. By observing the analysis results are shown the stress, strain and displacement values of the three materials. When comparing the stress values of the three materials, the stress values of other two materials are greater than the stress value of cast iron. The result of this paper, using cast iron as friction material is advantageous than using alloy steel and copper as friction material. The cast iron using as friction material is the best for single plate clutch.

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