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Theory Based On Conceptual Design of Single Plate Clutch for 1 Ton TOP Jeep

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Abstract: *A clutch is mechanism designed to connect or disconnect the transmission of power from one working part to another. It is locate between the engine and gearbox of the vehicles. It describes the design of the single plate clutch with diaphragm spring of 1 ton TOP jeep, which produces in SUN LIGHT group at Mandalay Industrial Zone. Clutches are designed to avoid the slip, design torque is considered by the capacity of 125% to 150% of the maximum engine torque for automobiles. At 2400 rpm of the engine speed, the maximum engine torque of 4 cylinders in line OHC is 162 N.m. It explains consideration and the calculation of friction radii for clutch plate, axial force, radii and thickness of the pressure plate, and length of the clutch pedal are presented.*

Key Words: *Diaphragm Spring, Engine Speed, Axial Force, Clutch Pedal.*

1. INTRODUCTION:

Nowadays, automotive vehicles are widely used in many countries for transportation and other purposes. So it is necessary to know about automotive vehicle engine in detail for mass production in our country. Automotive technology is also a required sector to develop the country rapidly. Transportation is vital to a nation's economy. Reducing the costs of transporting natural resources to production sites and moving finished goods to markets is one of the keys factors in economic competition. Some of many industries in the industrial zones produce jeeps to help the transportation of country. The jeeps for the transportation are using engines or motors to obtain driven power. They are composed of various mechanisms such as an engine, transmission system, suspension system, break system, lighting system, air conditioning and so on. Transmission system among them is essential for movement of jeep. This system consists of clutch, gear box, axial, propeller shaft, universal joint and differential. A clutch is a mechanism designed to connect or disconnect the transmission of power from one working part to another. In the production of the jeeps, clutches are used for the transmission system and the jeeps producers of our country are using the clutches from the foreign countries. Thus, the Myanmar engineers have a duty to design out of the good design of the clutch for the industrial zones that produce the jeeps for the public. In this paper, the transmission system of a car, operation and design calculation of single plate clutch used in the jeeps is presented.

2. OVERVIEW OF SINGLE PLATR CLUTCH OF THE JEEP :

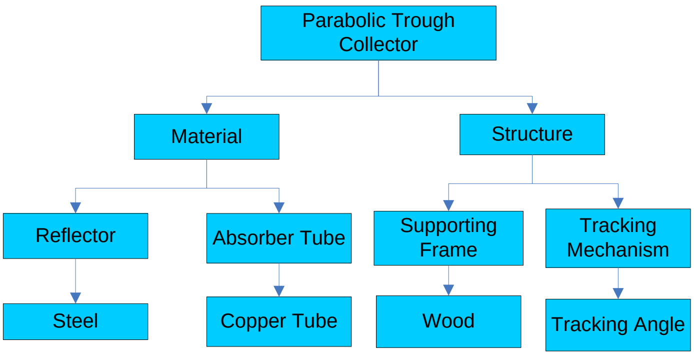

Figure 2.1. Classification of Clutches

The clutch is also defined as a form of coupling placed between the engine and the transmission that permit the drive to couple or uncouple the engine and the transmission. The purpose of the clutch is to uncouple temporarily the engine and the transmission so that the transmission gear can be shifted. The pressure between gear teeth in a set of gears through which power is flowing makes it hard to shift the gears out of mesh. Clutches are classified as shown in Figure 2.1, into three types by the engagement. When the driven assembly contains one clutch disc the clutch is known as single plate clutch.

3. DESIGN OF SINGLE PLATE CLUTCH:

A clutch of good design must have ability to dissipate heat, adequate reserve torque capacity (other than a slip clutch), and long life.

A. Friction Torque Acting on the Clutch

If the load is variable or subject to shock, additional service factors often are used. Suggested service factors are 1.5 for high speed in diesel engine.

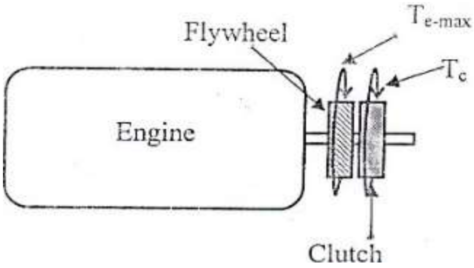

Figure 3.1. Torques for Clutch Engagement

$$SF = \frac{T_c}{T_{e,max}} \qquad 3.1$$

Where, SF = service factor
T_c = torque of clutch, Nm
$T_{e,max}$ = maximum torque of engine, Nm

Friction torque acting on the friction surface or on the clutch,

$$T_c = F_a \mu R_f n \qquad 3.2$$

Where, F_a = axial force, N
R_f = mean frictional radius of clutch, m
n = number of friction surfaces
μ = coefficient of friction

$$R_f = \frac{r_{c-o} + r_{c-i}}{2} \qquad 3.3$$

Where, r_{c-o} = outside radius of friction surface, m
r_{c-i} = inside radius of friction surface, m
The usual ratio of inside to outside radius of clutch disc are 0.6 ~ 0.8.

Axial force acting on the friction surface,

$$F_a = CF \text{ x Circumference} \qquad 3.4$$

Where, CF = constant

The intensity of pressure varies inversely with the distance, therefore,

$$CF = p.\ r \qquad 3.5$$

Where, p = pressure between the friction surface, N/m^2
r = radius, m

B. *Pressure Plate Design*

Equation 3.6 is used to calculate the thickness of pressure plate.

$$S_s = \frac{-3p}{4mt_{pp}^2(r_o^2 - r_i^2)}\left[r_o^4(3m+1) + r_o^4(m-1) - 4mr_o^2r_i^2 - 4(m+1)r_o^2r_i^2 \log_e\frac{r_o}{r_i}\right] \qquad 3.6$$

Where, S_s = allowable stress of the material, N/m^2
m = 1/γ, reciprocal of the Poisson's ratio
t_{pp} = thickness of the pressure plate, m
r_o = outside radius of the pressure plate, m
r_i = inside radius of the pressure plate, m

$$S_s = \frac{S_y}{N} \qquad 3.7$$

Where, S_y = yield stress, N/m^2
N = safety factor

C. Damper Spring Design

In the design calculation of damper spring used to lock the torsional force of the clutch plate is obtained by the Equation 3.8.

$T_{damper} = F_s n_s R_s$ 3.8

Where, T_{damper} = Lock torque of the damper spring, Nm
F_s = Force acting on the damper spring, N
n_s = number of the damper springs
R_s = distance from axis of clutch to axis of damper, m

$$R_s = R_{hub} + \left[\frac{r_{c-i} - R_{hub}}{2}\right] \quad 3.9$$

Where, R_{hub} = radius of hub, m
r_{c-i} = inside radius of clutch disc,m

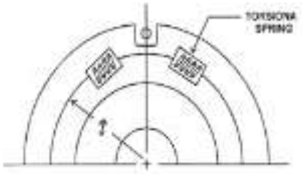

Figure 3.2. Location of Damper Spring

To find the diameter of the damper spring,

$$s_s = \frac{8KF_sC}{\pi d^2} \quad 3.10$$

Where, S_s = stress acting on the damper spring due to the clutch torque, N/m^2
K = Wahl factor
C = spring index

The ratio of the mean diameter of the spring to the wire diameter is called spring index C.

$C = D_s/d$ 3.11

Where, D_s = diameter of the spring coil, m
d = diameter of the wire, m

It is recommended that C be greater than 5, with typical machinery springs having C values ranging from 5 to 12. For round wire, C = 5.

$$K = \frac{4C-1}{4C-4} + \frac{0.615}{C} \quad 3.12$$

To find the deflection of the damper spring,

$$y = \frac{8n_cF_sC^3}{Gd} \quad 3.13$$

Where, y = deflection of the damper spring, m
G = modulus of rigidity, N/m^2
n_c = number of coil

To find the stiffness of the damper spring,

$k = F_s/y$ 3.14

Where, k = stiffness of the spring, N/m

D. Deflection of Diaphragm Spring

A Belleville spring or disc spring has the shape of a conical disk with a central hole, as shown in Figure 3.3. A very high spring force can be developed in a very small axial space with such springs.

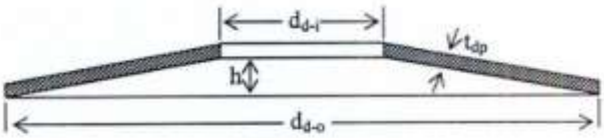

Figure 3.3. Disk Spring

The relation between the applied load and the axial deflection is obtained Equation 3.15.

$$F_a = \frac{Ey}{(1-\gamma^2)M\left(\frac{d_{d-o}}{2}\right)^2}\left[\left(h-\frac{y}{2}\right)(h-y)t_{dp} + t^3_{dp}\right] \quad 3.15$$

Where, E = modulus of elasticity, N/m^2

y = deflection, m
h = free height minus thickness, m
t_{dp} = thickness of diaphragm spring, m
γ = Poisson's ratio
$d_{d\text{-}o}$ = outside diameter of diaphragm spring, m

$$M = \frac{6}{\pi \log_e\left[\frac{d_{d-o}}{d_{d-i}}\right]}\left[\frac{\frac{d_{d-o}}{d_{d-i}}-1}{\frac{d_{d-o}}{d_{d-i}}}\right]^2 \quad 3.16$$

Where, $d_{d\text{-}i}$ = inside diameter of diaphragm spring, m
The ratio of outside to inside diameter of diaphragm spring should be between 1.5 ~ 5.

E. Pedal Design

In the design considering of pedal shown in Figure 3.4, related forces can be calculated by using Equation 3.17.

$$F_{foot} \times L_A = F_m \times L_B \quad 3.17$$

Where,
F_{foot} = force acting on pedal, N
L_A = distance between foot seat and push rod, m
F_m = force acting on master cylinder, N
L_B = distance between pivot and push rod, m

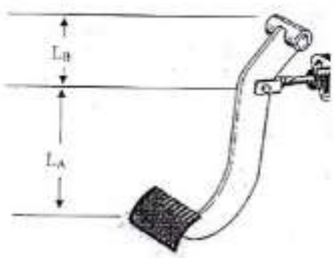

Figure 3.4. Clutch Pedal

4. DESIGN DATA OF THE ENGINE :

The 1 ton TOP jeep is produced by SUN LIGHT Group. Therefore, the data required for the single plate clutch design calculation are known the maximum torque of the engine used in the TOP jeep. The specification of the engine is as follows,

Type = 4 Cylinders in line Over Head Camshaft Diesel engine
Model = 2C
Piston Displacement = 1974 cc
Bore and Stroke = 86.0 × 85.0 mm
Compression ratio = 22.5: 1
Maximum torque = 162 Nm at 2400 rpm
Fuel system = Distribution type fuel injection
Engine oil capacity = 5 liters

5. DESIGN RESULTS OF THE SINGLE PLATE CLUTCH:

The table shows the results of the single plate design for 1 ton TOP Jeep. According to engine used in the 1 ton TOP Jeep made by SUN LIGHT group, its maximum engine torque is162. Torque of the clutch is obtained from the calculation by service factor and engine torque. And then, these values are used in calculation of the mean friction radius. Outside and inside diameters of the pressure plate are depending on the mean friction radius. In according with the clutch force, the lengths of clutch pedal and clutch fork, master cylinder and slave cylinder, the force acting on the diaphragm spring vary.

Table 5.1. Results of Design Calculation

Sr.No	Name	Dimension
1	Maximum torque of engine	162 Nm
2	Torque of Clutch	243 Nm
3	Mean friction radius of the clutch	0.10 m
4	Outside diameter of the clutch plate	0.24 m

5	Inside diameter of the clutch plate	0.17 m
6	Width of the friction surface	0.04 m
7	Outside diameter of the pressure plate	0.24 m
8	Inside diameter of the pressure plate	0.17m
9	Thickness of pressure plate	0.02 m
10	Number of damper springs	4
11	Diameter of spring wire	0.01 m
12	Diameter of spring coil	0.03 m
13	Outside diameter of the diaphragm spring	0.24 m
14	Inside diameter of the diaphragm spring	0.17 m
15	Thickness of the diaphragm spring	0.0025 m
16	High of the diaphragm spring	0.01 m
17	Number of diaphragm spring	15

6. DISCUSSIONS:

Clutch torque requirements are highest when the engine is running and the drive line is stationary. Friction clutch is engaged, there is no slip between the clutch plates and there is no loss of power in this form of engagement. The specific features of the operation of friction clutches are friction. In this design, the material of clutch plate is made of asbestos for friction lining and pressure plate is made of cast iron and coefficient of friction is chosen by contact surface of the material. The friction clutch is disengaged by pressing the pedal, the clutch plate is completely free from the engine and the shaft will stop. To prevent the slip, the lining of the clutch should be checked, avoid the entering of the oil and grease the clutch system and clean them if they enter and replace the pressure spring and worn parts. It is compact in design and requires only a small sized housing. The operating load is uniform on the clutch plate. Hence, single plate clutch is extensively employed in automobiles and it is till popular in vehicle industries.

7. CONCLUTIONS:

The design of single plate clutch based on maximum engine torque, clutch shaft and force on the clutch pedal by the driver. In this design calculation, the clutch torque is 1.5 times of the maximum engine torque. Therefore, the clutch can operate to overcome the slip and the clutch has good properties of vehicle starting. Moreover, the clutch pedal is designed to require a less effort by the driver. This clutch pedal linkage is hydraulic control because the mechanical linkage is more complicated than hydraulic. Lining material is made of asbestos. Thus, the clutch has wear resistance and higher temperature operation.

8. RECOMMENDATIONS:

The calculated values are a bit difference from existing design, but can be utilized satisfactorily. The design calculation data is nearly equal with actual existing data. In this design calculation, the clutch design is based on the strength point of view and frictional coefficient of the clutch plate is taken as a constant. Moreover, the designers can be used the calculation presented in this paper as a sample calculation of the clutch design calculation for the machine needed the clutch system. This paper can help to obtain the basic construction of the single plate clutch. By using this basic calculation of the clutch design, the coming engineer should try and modify to obtain more and more modern design.

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