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Design Modeling and Analysis of a Single Plate Clutch

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ABSTRACT:

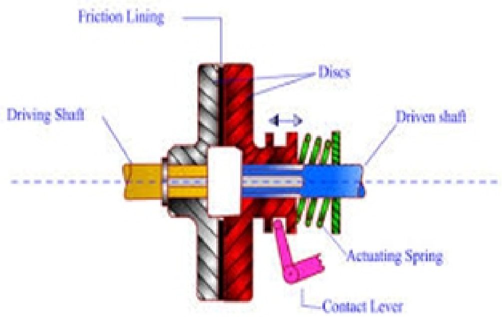
In design of the friction clutches of automobiles, knowledge on the thermo-elasticity a priori is very informative in the initial design stage. Especially, the precise prediction technique of maximum structural stress should be requested in design of mechanical clutches for their durability and compactness.In this study, a simple transmission system consisting of engine, clutch, gearbox and load is designed for the load lifting application. Stiffness of all the three shafts have been calculated and equivalent stiffness is calculated. Equivalent mass moment of inertia is also calculated. duration of engagement period is calculated for the selected power transmission system and energy dissipated during engagement is also plotted as a function of time. The effect of excitation torque and damping coefficient on the amplitude of vibration is plotted for various values of excitation speeds.

Keywords:

Clutch, Structural Analysis, ANSYS and proE.

INTRODUCTION:

The energy necessary for the motion of a vehicle is transmitted by the engine to the wheels through the flywheel, the clutch system and the driveline. The clutch takes the energy from the flywheel and transmits it to the driveline. During the engagement process, the friction torque acts upon the friction surfaces of the clutch as an engaging force for the driveline. A part of the energy transmitted through the driveline is transformed in to other forms of energy by positive damping effects.It is disengaged by operating the clutch pedal i.e. by pressing the pedal towards the floor of the vehicle. The clutch is engaged when the vehicle has to move and is kept in the engaged position when the vehicle is moving. The clutch also permits the gradual taking up of the load, whenproperly operated; it prevents jerky motion of the vehicle and thus avoids putting undue strain on the remaining parts of the power transmission. Single plate friction clutchThe parts of a single plate clutch can be seen below .It has only one clutch plate, mounted on the splines of the clutch shaft. This is the mostcommonly used type.The flywheel is mounted on the crankshaft, and rotates with it. The pressure plate is fixed on the flywheel through the pressure plate is fixed on the flywheel through the clutch springs. The plate rotates freely on the clutch shaft. It can also bemoved axially along the clutch shaft. The axial movement of the pressure plate is effected by pressing the clutch pedal. The end of the clutch shaft rests and rotates freely in the pilot bearing housed at the center of the flywheel.The splined portion of the clutch shaft carries the clutch plate whose details.



CLUTCH:

Clutch is a mechanism which enables the rotary motion of one shaft to be transmitted, when desired, to a second shaft the axis of which is coincident with that of the first.

FUNCTION OF CLUTCH:

1.Clutch is use the function of clutch to engage and disengage the engine power from gear box or wheel.
2.Effortless operation.
3.Minimum size.

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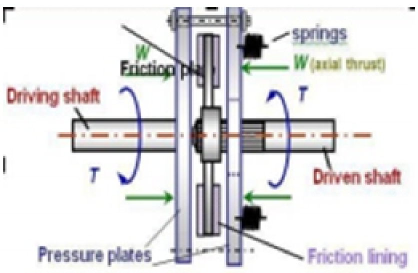
4.Minimum mass.
5.Torque transmission will be more.
6.Friction capacity will be more.
7.Heat dissipation will be more.
8.Minimum vibration.
9.Well balance.

Types of clutch:

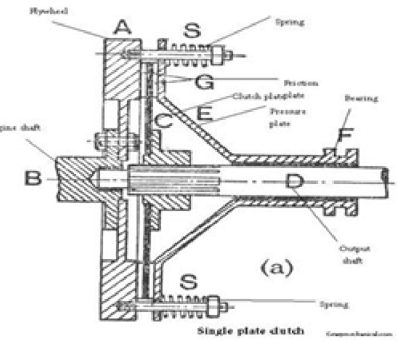
•Single plate clutch.
•Diaphragm type clutch.
•Multiplate clutch.
•Helical type single plate clutch.
•Centrifugal clutch.
•Cone clutch.

Single plate Clutch:

The parts of a single plate clutch can be seen below .It has only one clutch plate, mounted on the splines of the clutch shaft. This is the most commonly used type. The flywheel is mounted on the crankshaft, and rotates with it. The pressure plate is fixed on the flywheel through the pressure plate is fixed on the flywheel through the clutch springs. The plate rotates freely on the clutch shaft. It can also be moved axially along the clutch shaft. The axial movement of the pressure plate is effected by pressing the clutch pedal. The end of the clutch shaft rests and rotates freely in the pilot bearing housed at the centre of the flywheel.The splined portion of the clutch shaft carries the clutch plate whose details are shown in the figure



The clutch plate consists of two sets of facings of friction material mounted on steel cushion springs.



The facings and the waved cushion springs are riveted to a spring base disc and spring retainer plate. The waves of the cushion springs compress slightly as the clutch engages and thus provide some cushioning effect. The base disc and the spring retainer plate are slotted for inserting the torsion springs. These torsion springs contact the hub flange that fits between the spring retainer plate and the disc.

The principle of this device is that the driven plate is not rigidly connected to the hub of the driven shaft but left free rotationally thereon and is connected through a number of mall spring's blocks. As such, these torsion springs serve to transmit the twisting force applied to the facings, to the splined hub. The spring action serves to reduce tensional vibrations and shocks between the engine and the transmission during clutch operation. By this arrangement, certain tensional vibrations of the crankshaft that have given rise to noise in the gear box are damped out and noise is eliminated.

When the clutch gets engaged, the facings and the plates rotate with respect to the hub to the limit of the compression of the torsion springs or to the limit of the springs stops. When the clutch is engaged, the pressure on the facing compresses the cushion springs sufficiently to cause the unit to decrease in thickness by 1.0 to 1.5 mm. This construction helps clutch engagement to be smooth and chatterless.

The single plate clutch in the engaged from as well as in the disengaged from can be seen in Fig. Due to the clutch spring force, the clutch plate is gripped between the flywheel and the pressure plate. Due to friction between the flywheel and clutch plate and the pressure plate, the clutch plate revolves. The clutch shaft which carries the plate also revolves. Clutch shaft is connected to the transmission. Thus, the engine power is transmitted from the crankshaft to the transmission unit.

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Clutch Plates in Automobiles and Motorcycles :

Clutch plate in a car is controlled by the left-most pedal. This makes use of hydraulics or a cable connection. The clutch may be physically located in close proximity to the pedal, but remote means of actuation are required to remove the effect of slight engine movement. If there is no pressure on the pedal, it means that the clutch plates are engaged.

It gets disengaged once the clutch pedal is depressed. Cars can also function with manual transmission. In this there are cogs that have matching teeth to synchronize the speed. One can select gears with the help of these cogs. In motorcycles, the clutch is operated by the clutch lever. One can engage the clutch plate by applying no pressure on the lever. Pulling the lever back towards the rider disengages the clutch plates. Slipper clutch plates are often used by racing motorcycles to get rid of engine braking.

Structural Analysis:

Structural analysis comprises the set of physical laws and mathematics required to study and predicts the behavior of structures. The subjects of structural analysis are engineering artifacts whose integrity is judged largely based upon their ability to withstand loads; they commonly include buildings, bridges, aircraft, and ships. Structural analysis incorporates the fields of mechanics and dynamics as well as the many failure theories.

From a theoretical perspective the primary goal of structural analysis is the computation of deformations, internal forces, and stresses. In practice, structural analysis can be viewed more abstractly as a method to drive the engineering design process or prove the soundness of a design without a dependence on directly testing it.

It includes the following methods,

•Analytical Methods
•Strength of materials methods (classical
•methods)
•Finite element methods (FEM)

Modeling of Clutch

Specification:

Model- TATA 475 IDITC
Maximum power - 51.5 kW @4800rpm
Maximum torque- 124 Nm @ 2800rpm
Capacity-1405cc

Pressure plate:

Internal diameter = 150mm
Pressure plate Outer diameter = 200mm
Rim diameter= 25mm

Clutch plate :

Material: Structural steel
External diameter= 200mm
Width=9mm

Flywheel:

External diameter= 250mm
No. of teeth=122

Spring;

Length=30mm
Outer diameter = 15mm
Inner diameter= 13mm

Release bearing;

Outer diameter=40mm
Inner diameter-30mm
Hook distance=75mm

Calculations:

Outer diameter (Do) = 200 mm
Inner diameter (D1
= 150 mm
No. of spring = 9
µ = 0.35
r1/ r0 = 100/115
= 0.869
Fa = 9X625
= 5.625 KN
Torque Capacity of New Clutch (T)

$$\tau = \frac{2}{3} \cdot \mu W \times \frac{R^3 - r^3}{R^2 - r^2} \; * N_f$$

= 2/3 X 0.3X 5625 ((0.1153-0.133) / (0.1152-0.132)) X2
= 363.401 N-m
= 0.363401kN-m
Torque Capacity after Initial Wear,
T = u FaDmNf/ 2
= 0.3X5625X(230+200/2)X2 / 2
= 362.81 N-m
Safety Factor when New = T / 124
= 363.401/124
= 2.930
Safety Factor after initial wear = 362.810/124
=2.925
Reduction in clamping force so that Slippage Occurs,
New Clamping Force
Fa1= 5.625X103 X 124/ 362.81
= 1.9224 KN
Change in Clamping Force,
Fa'= 5.625-1.9224
= 3.703 KN
Change in Clamping Force of each spring,
= 3.703/4
= 0.9257 KN
Spring Stiffness = 625/6.5
= 96.15 N/mm
Required Wear = 925.7 / 96.15
= 6.928mm
For design of spring:
Max. Force = 625X1.1
= 687.5 N
(10% extra force for disengagement)
Spring stiffness = 96 N/mm
For automotive clutch springs, select Cr-V Steel SAE.6150
Allowable Shear Stress with a F.S. = 1.2
τmax = Sys / 1.2
Sys = 770

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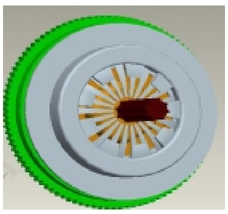
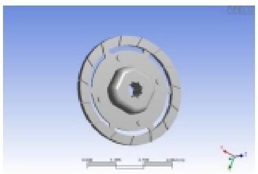
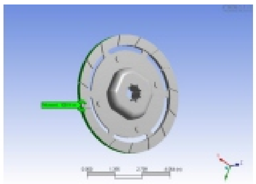
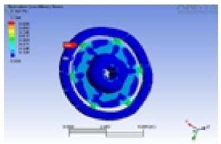
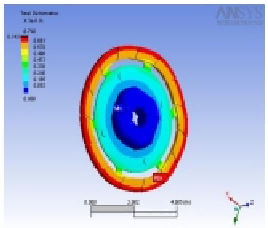
$\tau_{max} = 770 / 1.2$
$= 641$ Mpa
Assuming Wahl Factor, $C = 6$
$K = ((4X6 - 1) / (4X6 - 4)) + (0.615/6)$
$= 1.25$
$\tau_{max} = 8F_{max}.D_mK / \pi d3$
$= 8FCK / \pi d2$
$= 8X687.5X6X1.25 / \pi d3$
$= 513$
$d = 5.06 = 5$mm (say)
$Dm = 5X6$
$= 30$mm
To find the no. of turns,
$Ks = 96$
$= Gd / 8C2n$
$G = 85X103$
$n = (85X103X5) / (8X63X96)$
$= 2.56$
Total No. of turns with Squared and Ground ends,
$= 2.56+2$
$= 4.56$
$= 5$ (say)
Free length $= 5X5 + 687.5/96 + 4$
$= 36.16$mm
Free length/ Dm $= 36.16 / 30$
$= 1.2$, so ok
To check whether nine springs can be accommodated.
Mean Diameter of the Friction Disc $= (230+200) / 2$
Space available/ spring $= \pi X 215 / 4$
$= 168.86$ mm
Do of spring $= Dm + d$
$= 30+5$
$= 35$mm, so ok.

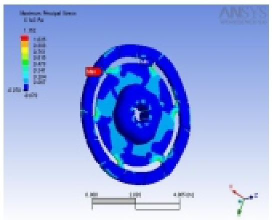












CONCLUSION:

This Projectis analysis in CAE software i.e. ANSYS based on the values of Equivalent stresses for material loading conditions it is clearly seen that these are less than the allowable stresses for that particular material under applied conditions the part not going to yield and hence the design is safe.The result occurred are quiet favorable which was expected. The stresses as well as deformation clear the idea about what parameter should have been taken into account while defining the single plate friction clutch.

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