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Design modification and Failure Analysis of Damper Spring of 310 D.P.A of Single Plate Clutch System

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Abstract—Clutch is device which is used to transmit power one component to another. It is a device used to connect the driving shaft to a driven shaft, so that the driven shaft may be started or stopped at will, without stopping the driving shaft. A clutch thus provides an interruptible connection between two rotating shafts Clutches allow a high inertia load to be stated with a small power. The engine power transmitted to the system through the clutch. The failure of such a critical component during service can stall the whole application.

The objective of present project is to do analysis on driven plate assembly (D.P.A) of a clutch which is often fails during the operation. In this present research work analysis is conducted on driven plate of a clutch used in TATA Vehicle. There are so many complaints are noted against the failure of clutch during heavy loads. The damper spring of driven plate assembly failed normally during its operation due to cyclic loading. For this reason we designed the damper spring and modeled in Pro-E and analyzed using FEA package in the process of designing and analyzing the actual design is changed to lower down the failure values. And the design may suggest to the company.

Keywords—Single plate clutch system; Damper spring; Failure analysis; Fatigue, Ansys

I. INTRODUCTION

The power developed inside the engine cylinder is ultimately aimed to turn the wheels so that the motor vehicle can move on the road. The reciprocating motion of the piston turns a crankshaft rotating the flywheel through the connecting rod. The circular motion of the crankshaft is now to be transmitted to the rear wheels. It is transmitted through the clutch, gearbox, universal joints, propeller shaft or drive shaft, differential and axles extending to the wheels. The application of engine power to the driving wheels through all these parts is called power transmission

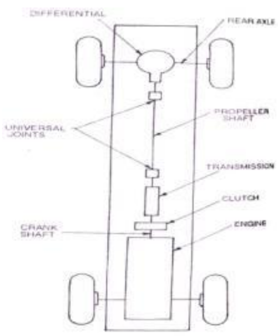

Fig.1 Automobile Power Transmission System

The power transmission system is usually the same on all modern passenger cars and trucks, but its arrangement may vary according to the method of drive and type of the transmission units. Fig 1.1 shows the power transmission of an automobile. The motion of the crankshaft is transmitted through the clutch to the gear box or transmission, which consists of a set of gears to change the speed. From gear box, the motion is transmitted to the propeller shaft through the universal joint and then to the differential through another universal joint. The differential provides the relative motion to the two rear wheels while the vehicle is taking a turn. Thus the power developed in the engine is transmitted to the rear wheels through a system of transmission. Clutch is a device used in the transmission system of a motor vehicle to engage and disengage the engine to the transmission. This device is used to transmit the power on user will.

II. PROBLEM DEFINATION

From warranty department get maximum complain about damper spring broken from driven plate assembly of 310mm Single plate clutch system (As shown in fig.2).

Fig.2: Photo of 310 D.P.A (damper spring broken)

For our problem we proceed by using root cause analysis by Fish Bone diagram. It is very effectively use in manufacturing industries to find out the reason of the problem.

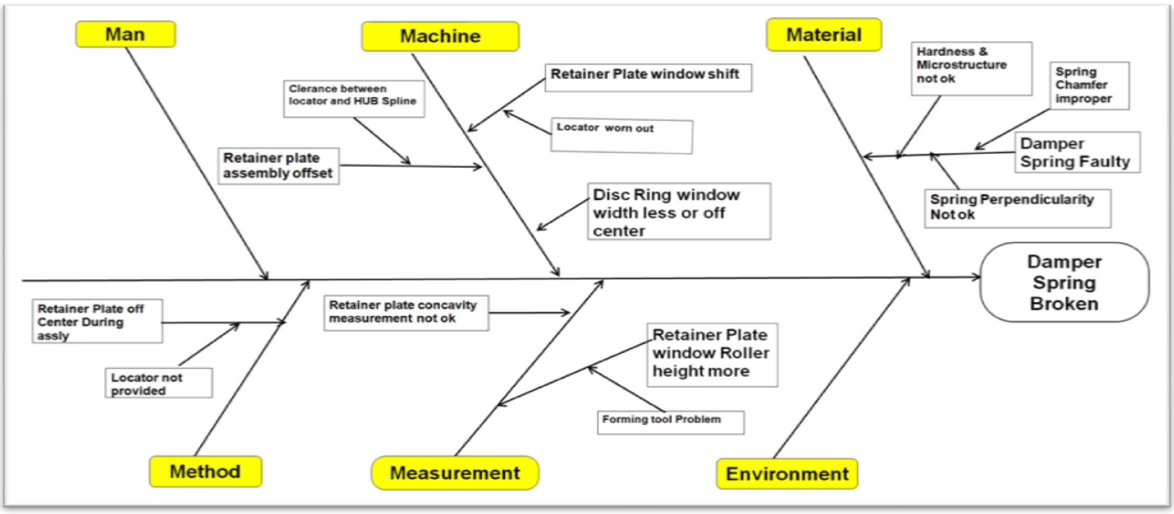

Fig.no.3: Fish bone diagram.

III. METHODOLOGY

310 DPA are used in TATA LPT 1109 so, to proceed we need the some parameter and specification which given in below table.

Table 1(A): SPECIFICATION OF MODEL TATA LPT 1109

MODEL	TATA 497 TCIC
MAXIMUM POWER	90 H.P @ 2400 RPM
MAXIMUM TORQUE	400 N.m @ 1300-1500 RPM
CAPACITY	3783 CC
CLUTCH	SINGLE PLATE DRY FRICTION TYPE (310 MM DIA)

Table 1(B): MATERIAL PROPERTIES OF SPRING

MECHANICAL PROPERTIES	
Tensile Strength (N/mm^2) @ wire dia. of 5.385 mm.	1750-1910 to 1710-1860
Permissible Depth of Surface Defects (mm)	0.8% of nominal wire
Modulus of rigidity	79500 N/mm^2

3.1. DESIGN OF HELICAL SPRING

Consider a helical compression spring made of circular wire and subjected to an axial load W.

1. MEAN COIL DIA(D) = Di + Do / 2
   = 23.83 + 13.06 / 2 = 18.445 mm
2. SPRING INDEX (C) = D /d
   = 18.445/5.385 = 3.42
3. WAHL'S FACTOR (K) = Ks + Kc = (4c – 1/4c -4) +(0.615/C) = 1.4882
4. TORSION SHEAR STRESS (S) = T*r / J = $8PD/\pi d^3$ = 517.65 N/mm^2

In order to consider the effects of both direct shear as well as curvature of the wire, a Wahl's stress factor (K) used.

5. TORSION SHEAR STRESS (S)= K * $8PD/ \pi d^3$ = 770.27 N/mm^2
6. DEFLECTION OF SPRING (δ) = $8PD^3N /Gd^4$ = 5.169 mm
7. SPRING RATE (K_s) = P / δ = 332.94 N/mm

In calculation the spring parameters the Torsional yield strength (S_{ys}) is used. The relationship between the torsional yield strength and ultimate strength (S_{ut}) can be approximated with as follows. S_{ys} = 0.50 бut So, our stress is **770.27 N/ mm^2** which is less than allowable limit **(875 N/mm^2)** so, our design for shear stress is safe in static loading.

When the springs subject to the load that alternates from Fmin to Fmax, the stresses for springs can be obtained from equation (a) and equation (b) [6]. The fatigue strength condition is

S= (*Es*+0.75*t* P mi n) /*t*=[*S*]

Where Es= Max is endurance limit of the spring for a zero plus cycle, which can be found in table [*S*] is allowable factor of safety, if accuracy of design calculation and mechanical properties is higher, then [*S*]=1.3~1.7, if lower, [*S*]=1.8~2 [6].

Table 2: Endurance limit of the spring for a zero-plus cycle

Number of cycles of the stress N	10^4	10^5	10^6	10^7
Es	0.45бut	0.35бut	0.33бut	0.3бut

Table 3: Ultimate tensile strength of TDSiCr spring material бut (Mpa)

Wire diameter (mm)	2.5 to 3.5	4.5 to 5.6
Ultimate tensile strength(Mpa)	1860-2010	1760-1910

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So according to above equation the endurance limit (Es) = 577(Mpa) and F.O.S = 1.16 which is same so validated according to the reference paper. So According to shear stress no. of life cycle is lying about 10^4. So it is say to be a very low as per the requirement of clutch.

3.2 Finite Element Analysis

For Standard spring model analysis by ANSYS 15.0 in which first input data , material properties, element shape and size and then boundary condition apply. And find out the result of shear stress, maximum deflection and factor of safety.

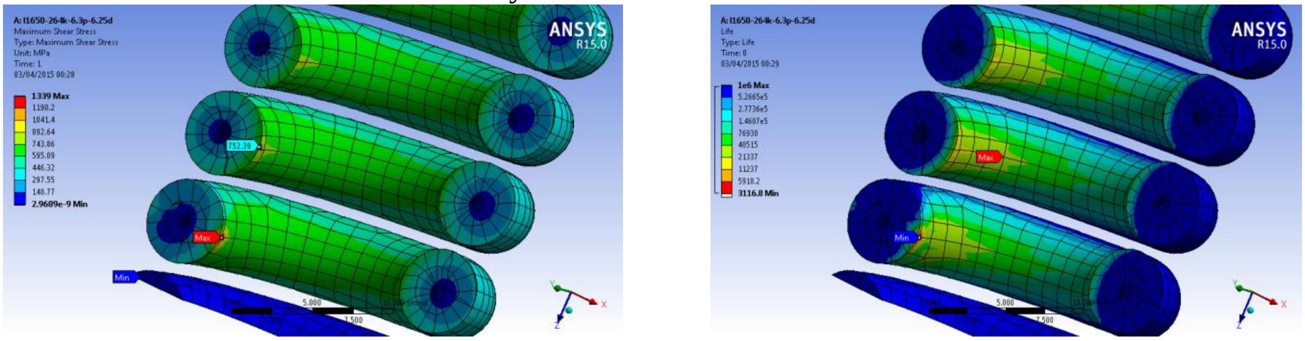


Fig.4: Cut section model of Spring with max. shear stress and safe life

Table 4: Result Table

PARAMETER	1650 N	1710 N	1742 N	1782 N
Max. Shear Stress (N/mm^2)	1339	1433	1498	1446
Max. Deformation (mm)	6.251	6.486	6.608	6.758

3.2 Modified Design of spring

Specification of Modified variant springs: Here we took the two different variant of springs as according to change dimension, changing pitch and using nested spring. Specifications are shown in following table.

Table 5: Specification for modifying spring model

Specification	Model -1	Model-2 (Outer)	Model-2 (Inner)
Wire dia (d) mm.	5.893	5.385	2.032
Mean.dia (D) mm.	17.808	18.445	07.36
Pitch	7.3	6.3	6.3

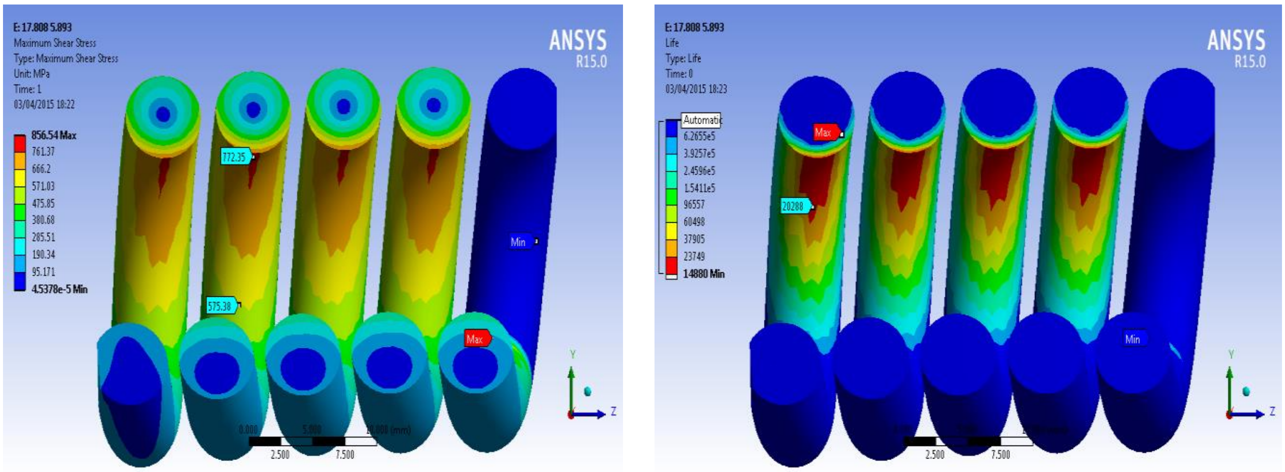
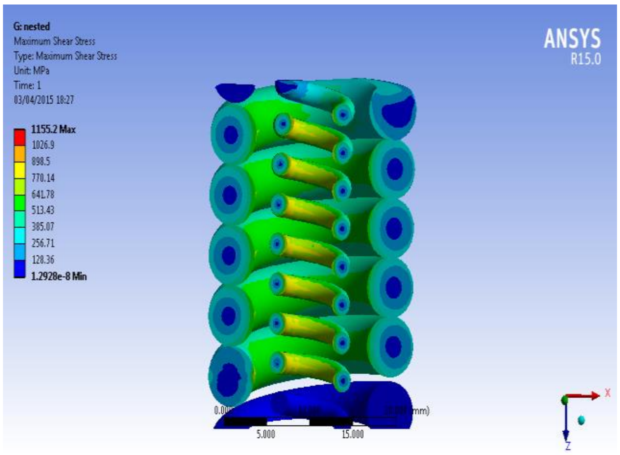


Fig.5: Modify Model-1 of Spring with Max.shear stress and Safe life.



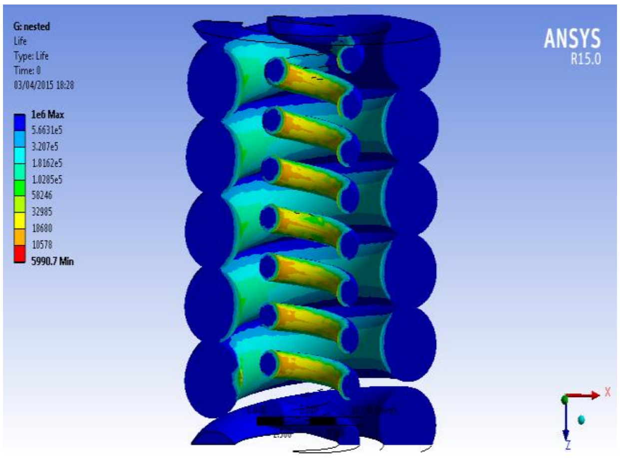


Fig.6: Modify Model-2 of Spring with Max.shear stress and Safe life.

IV. RESULT AND CANCLUTION

Table 6: Result Table

PARAMETER	Model no.1	Model.no.2 (Nested Spring)
Load (N)	1650	1650
Max. Shear Stress (N/mm^2)	856.54	1155.2
Max. Deformation (mm)	5.339	5.309
Safe life cycle	14880	5990

4.1 CANCLUTION

The present work is investigation on Reduction in Premature Failure of Damper Springs subjected to static and cyclic loading conditions. As from the analysis result of the actual spring models maximum value of Shear stress is very near to the theoretical Shear stress.

From FEA analysis of Modifying models we find out the different values of Max. Shear stress, Max Deformation and Safe life of spring Result as shown in below table 6.

If we increase wire diameter 5.385 to 5.893mm the value of shear stress largely reduce from 1339Mpa to 856Mpa and in model no.1.

And also max safe life cycle is improving 3116 to14880.

Finally conclude that spring strength effected by varying diameter of spring coil and at maximum diameter spring expected to lose the elastic property and unsuitable for the service.

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