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Vibration Analysis of Diaphragm Spring of Clutch by Experimental Method

Rajendra S. Chaudhari[1], Harshal S. Deore[2], Kiran B. Gore[3]

[1]*Department of Mechanical Engineering,SNJB's KBJCOE, Chandwad, rajendraschaudhari@rediffmail.com*
[2]*Department of Mechanical Engineering, SNJB's KBJCOE, Chandwad, harshal.deore@gmail.com*
[3]*Department of Mechanical Engineering, SNJB's KBJCOE, Chandwad, Kirangore1987@gmail.com*

Abstract - This paper investigates the vibration behavior of a diaphragm spring of clutch. The diaphragm spring rotates with a constant angular speed. A diaphragm spring is an important component of a clutch assembly, characteristic of clutch depends largely on that of a diaphragm spring. The vibration of a diaphragm spring affects the working efficiency and decreases the mechanism's capabilities of clutch. The diaphragm spring consist of periodic radial slots. In this work Free and forced transverse vibration characteristics of a diaphragm spring have been investigated by experimental approach. The inner edge of the diaphragm spring is clamped while the outer edge is kept free. Experimental analysis has carried out with the help of FFT analyzer and suitable instrumentation. Natural frequencies are detected by hitting the plate with impact hammer; the response at a point of a diaphragm spring is measured by using an accelerometer. FFT analyzer analyzes the output of accelerometer. Finally the Experimental results are validated with previous work.

Keywords- Diaphragm spring, vibration, Modal analysis, FFT Analyzer, Accelerometer. Electrodynamics exciter, Impact hammers.

I. INTRODUCTION

The clutch is an important component in the transmission of the automotive, whose main function is to assurance the smooth start of the car and steady run when the transmission has a gear change. Due to the unique nonlinear characteristic, simple structure and stable operation, the diaphragm spring clutch has wide applications. Therefore clutch diaphragm spring is selected for analysis purpose. In clutch system the various parts like pressure plate pivot rings, friction plate and diaphragm spring creates the vibration and noise. The pressure plate is believed to be the main source for generating the noise. Currently the industries do not have an effective analytical tool to quantify the Noise and Vibration produced in a Drive train. Therefore, it is needed to find out amount of vibration in Diaphragm spring

When an Impact is applied on the Diaphragm spring, it vibrates, and subsequently produces pressure waves in the surrounding air. Its vibration frequencies and pressure waves can be measured by a Noise and Vibration test. Once the natural frequencies and mode shape are detected, it can be further expanded to predict Noise and Vibration in a Drive train, and to suggest design alternative to eliminate Noise and Vibration. Hence the knowledge of natural frequencies of Diaphragm spring is of great interest in the analysis of vibration behavior of Diaphragms spring to various excitations.

1.1 Diaphragm Spring

The diaphragm spring is a round, conical shaped spring that provides the clamping force against the pressure plate. Pivot rings are installed on both sides of the diaphragm spring. They serve as a pivot point when the release bearing is forced against the diaphragm spring. There are two types of diaphragm springs as Pull diaphragm spring and Push diaphragm spring. The function of these two types of springs is same. The term relates to the way the clutch works, whether the clutch plate is pulled or pushed away from the flywheel. The clutch can only move in one direction, away from the flywheel, but it's the action of the clutch diaphragm spring whether it works by lifting the pressure plate or by pressing it that gives the clutch its name. Pull clutches are better for highly tuned cars as they offer better clamping force so can take the higher pressures created to combat the extra torque of the engine, without the clutch slipping for lower pedal effort. Diaphragm springs can then be made stronger.

II. PROBLEM DEFINATION

The main aim of this work is to study the vibration behavior of diaphragm spring means to find out natural frequencies and different mode shapes. The boundary conditions are the inner edge of diaphragm spring is clamped while outer edge free. The knowledge of natural frequencies of component is of great interest in the analysis of response of structures to various excitations. This study is fundamental for high-risk plants. Unwanted noise, vibration and accidental failure associated with the different clutch components like pressure plate diaphragm spring clutch cover etc. has become an important economic and technological problem in the transmission system that can be solved by this work. Previous FEM results are also validated with Experimental Method by using FFT Analyzer and Electrodynamics Exciter.

2.1 Test Specimen

Fig.1 Diaphragm Spring of Clutch specimen.

Table No.1.Test Specimen-I Dimensions of Diaphragm Spring of Clutch

Diaphragm spring Specimen	Aspect ratio a/b	Inner diameter in mm (a)	Outer diameter in mm (b)	Number of Slots.	Length of slots in mm
1^{st}	0.385	61	235	20	60

2.2 Diaphragm Spring Material

The material of the diaphragm spring of the clutch is 50 Cr V4 cold rolled steel and its properties are as follows.

Young's modulus (E) = 2.1×10^5 N/mm^2
Poisson's ratio (γ) = 0 .3
Density of material (ρ) = 7830 Kg/m^3
Tensile strength = 100-1300 Mpa
Elongation = 10 %
Yield strength = 900 Mpa

III. EXPERIMENTAL ANALYSIS

3.1 Testing of Diaphragm Spring

Figure 2 and 3 shows the text fixture for impact hammer test means FFT test and exciter test. Clamping is obtained by using two 80 mm washers of 1 mm thickness, upper and lower side of diaphragm spring with 20 mm diameter nuts and one bolt with two washers are fastened above and below the diaphragm spring. The fixture is hold in vice, which is rigidly fixed on concrete foundation with nut bolts. Bolt is used to restrict the movement at inner edge of Diaphragm spring in x and y and z direction. Sufficient care is exercised to tighten the bolts with 8 kg-m constant torque provided by torque range spanner, uniformly to achieve the fixed end condition.

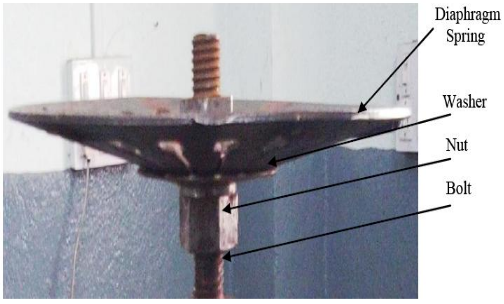

Fig. 2 Clamping Details of Test (Front View)

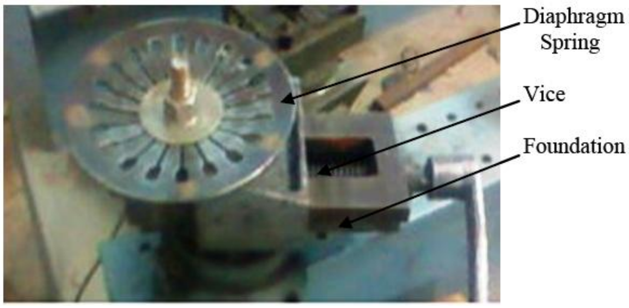

Fig. 3 Clamping Details of Test Specimen (Top View)

3.2 Impact Hammer Test

Test specimen diaphragm spring of Tata 407 is tested by impact hammer test i.e. FFT test and Exciter test. The main aim of these test are to find out the different natural frequencies and mode shapes. Figure 5 shows a impact hammer test setup. The impact hammer is used to hit or impact the diaphragm spring being tested to excite a wide range of frequencies. The impact hammer is simple portable, inexpensive and much faster to use than exciter. It is a built up force transducer in its head. The shape of frequency response is dependent on the mass and stiffness of the hammer and diaphragm spring. The impact force caused by impact hammer, which is nearly proportional to the mass of the hammer head and the impact velocity. It can be found from the force transducer embedded in the structure at an impulse is composed of excitation at each of the natural frequencies of the diaphragm spring.

The accelerometer is mounted on the diaphragm spring. A wax type material is used to mount the accelerometer on the non-magnetic material. The benefit of use of accelerometers is that they do not require a calibration program to ensure accuracy. From the accelerometer record, the velocity and displacement are obtained. It is a linear seismic transducer utilizing a piezoelectric element in such a way that an electric charge is proportional to the applied acceleration Piezoelectric accelerometers utilize a variety of seismic element configurations. Here motion of the vibrating body is converted into an electrical signal by the vibration transducer. In general a transducer is a device that transforms the signal changes in mechanical quantities such as displacement, velocity, acceleration, force changes into electrical quantities such as voltage, current. Since the output signal conversion instrument is used to amplify the required value. The output from the signal conversion instrument can be presented on display unit for visual inspection, or by recorder by recording device or stored in a computer for later use.

FFT analyzer is an electronic device that is capable of taking the time waveform of a given signal and converting it into its frequency domain. Depending upon the quantity measured a vibration measuring instrument is called a vibrometer, a velocity meter, an accelerometer, a phase meter, or a frequency meter.

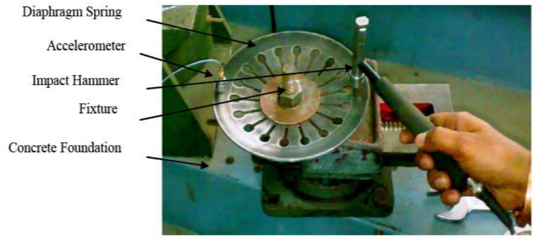

Fig. 4 Experimental Set Up for Impact Hammer FFT Test

Following are the graphs obtained from FFT testing of diaphragm spring of TATA indigo car clutch

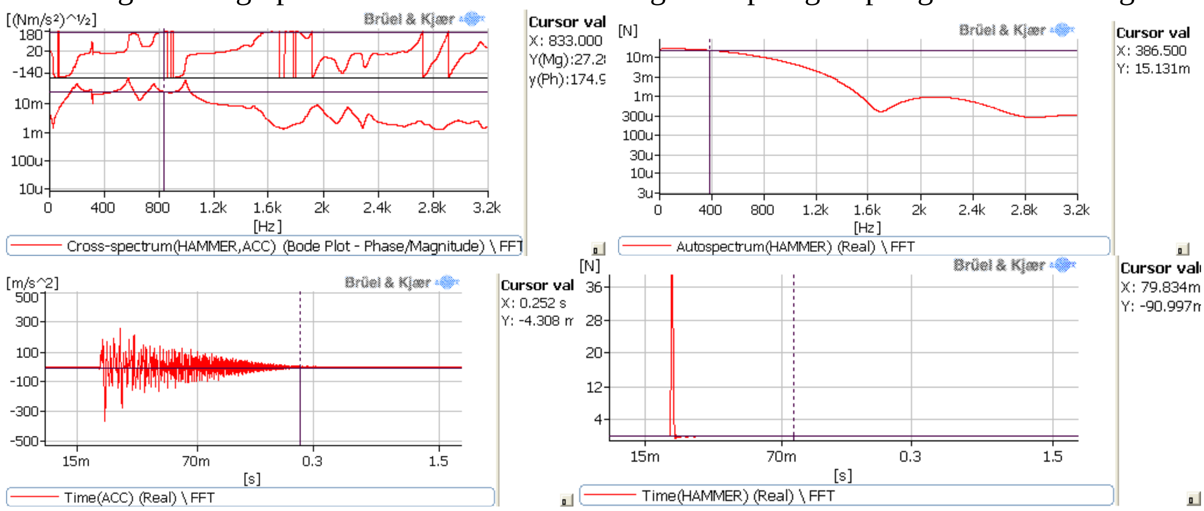

Fig. 5 Graph Obtained from FFT Analyzer.

Table No.2. First 6 Natural Frequencies of Diaphragm Spring of TATA 407 Clutch

Sr. No.	Mode(c, d)	Experimental Natural Frequency in Hz
1	(1,0)	314
2	(0,1)	330
3	(0,2)	432
4	(0,3)	698
5	(0,4)	1112
6	(0,5)	1676

3.3 Exciter Test

Diaphragm spring assembly is mounted on exciter as shown in Figure 6 pressed by a set of nut and clamping bolts. Sufficient care is exercised to tighten the bolts with 8 kg-m constant torque provided by torque range spanner, uniformly to achieve the fixed end condition. Sea shore sand is spread on the diaphragm spring. The diaphragm spring is excited by varying the exciting frequency on electrodynamic exciter to obtain resonance condition. At resonance condition the diaphragm spring is vibrate at maximum amplitude and different mode shapes are obtained.

Fig. 6 Experimental Set Up For Exciter

Following are the mode shapes of diaphragm spring for TATA 407 as shown in figure7. Different mode shapes are detected by spreading sea shore sand on spring and by varying the exciting frequency.

Fig.7 Mode Shape Showing Two Nodal Diameters & Four Nodal Diameters

DISCUSSION OF RESULTS

After experimentation the results are validated by Ansys results from previous results. Discussion on results obtained by theoretical and experimental analysis is carried out here to reach the conclusion. Differences in results are compared for boundary conditions for specimen are inner edge fixed and outer edge free.

5.1 Comparison of Results of Diaphragm Spring

In FFT testing, diaphragm spring of TATA 407 clutch is tested successfully with FFT analyzer **(**impact hammer testing) to get natural frequencies. Also theoretical natural frequencies are considerd from previous work and both results are compared. Table 3 shows comparison of results of natural frequency by FEM/ANSYS and FFT (Impact hammer results) of diaphragm spring. Figure 8 shows natural frequency by ANSYS results verses FFT (Impact hammer results) of diaphragm spring.

Table No. 3. Comparison of Theoretical and Experimental Natural Frequency

Sr. No.	Mode(c, d)	Theoretical Natural Frequency in Hz(FEM)	Experimental Natural Frequency in Hz
1	(1,0)	325.31	314
2	(0,1)	339.55	330
3	(0,2)	440.21	432
4	(0,3)	701.15	698
5	(0,4)	1121.8	1112
6	(0,5)	1685	1646

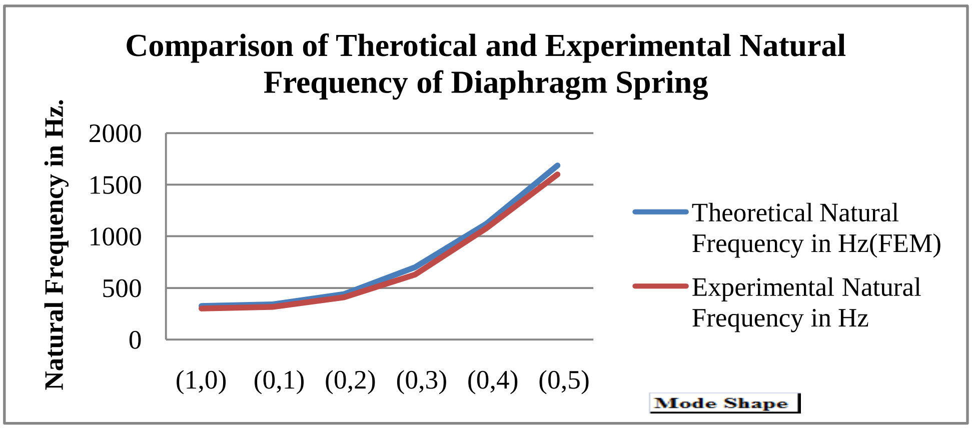

Fig. 8 Natural frequency plots for Theoretical results (FEM) and Experimental Results

Natural frequency increases with increase in nodal diameter and results are matched with least error when compared with ANSYS and Impact hammer FFT test for TATA 407 clutch.

CONCLUSION

In experimental testing, the diaphragm spring of TATA 407 clutch is tested successfully with FFT analyzer and impact hammer. Natural Frequency of diaphragm spring Increases with increase in nodal diameter. The various dimension parameters of diaphragm spring should be the optimized between vibration parameter and load carrying capacity. From this analysis I have concluded that, for better performance and efficient working of diaphragm spring the resonance condition should be avoided because at different natural frequencies of diaphragm spring the spring vibrates at it's at maximum amplitude and resonance condition the spring may be fail. Therefore at the time of design diaphragm spring natural frequencies mode shape and speed of diaphragm spring should be considered. In analysis natural frequency obtained from FFT results is less than FEM results due to the boundary condition, damping, inertia effect and double hit of impact hammer, therefore to obtain the accurate result from experimental method there should be a more concentration on these factors.

REFERENCES

[1] Albert Albers, Daniel Herbst, "Chatter Causes and Solutions", pp. 23-45.

[2] A. S. Bouboulas and N. K. Anifantis, "Vibration Analysis of a Rotating Disk with a Crack" Volume 2011, Article ID 727120, International Scholarly Research Network ISRN Mechanical Engineering.

[3] K.D.Wang, Kalyan Bairavarasu, "Noise and Vibration Analysis by Finite Elements" 2005, pp. 1-10.

[4] Pietro Jacopo Dolcini, "Contribution to the Clutch Comfort", Phd Thesis, May 9, 2007, pp. 9-12.

[5] Wook-Hee Nam1, Choon-Yeol Lee, Young S. Chai, "A Study on Fatigue and Durability Characteristics of Clutch Diaphragm Spring According to Tempering Condition", Seoul 2000 FISITA World Automotive Congress, June 12-15, 2000, Seoul, Korea, pp. 1-5.

[6] Wook-hee NAM, Choon-yeol LEE, Young S. CHAI Jae-do KWON, "Finite Element Analysis and Optimal Design of Automobile Clutch Diaphragm spring", Seoul 2000 FISITA World Automotive Congress ,F2000A125, June 12-15, 2000, Seoul, Korea, pp. 1-5.

[7] R.S. Chaudhari, "Vibration Analysis of Diaphragm Spring of a Clutch", International Journal of Innovation in Mechanical and Automobile Engineering, ISSN: 2249- 2968, IJIMAE -March 2012, ISSUE – II, pp.197-202.

[8] R. S. Chaudhari, "Vibration Analysis of Diaphragm Spring of Clutch by Finite Element Method" in Proceeding of ICRTET 2013, ISBN No.: 978-81-926080-0-6/22-24 Feb 2013.

[9] R. S. Chaudhari, "Vibration Analysis of Diaphragm Spring of Clutch by FEA" in Proceeding of ICRTET 2014, published by ELSVIER publication, ISBN No.:978-93-5107-222-5, March 28-30,2014.

