Design, Development & Analysis of Dual Mass Flywheel Spring

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Abstract- *All engines have flywheels or weighted crankshafts that balance out compression and power strokes, maintain idle speed, aid starting and reduce parts wear. Dual mass flywheel is a multi-clutch device which is used to dampen vibration that occurs due to the slight twist in the crankshaft during the power stroke. The torsional frequency is defined as the rate at which the torsional vibration occurs. When the torsional frequency of the crankshaft is equal to the transaxles torsional frequency an effect known as the torsional resonance occurs. When the operating speed of the engine is low, vibration occurs due to the torsional resonance and this can be avoided using dual mass flywheel Spring. This work is carried out to study the effect of arc springs on the dual mass flywheel. The main aim is to increase durability of the arc spring and to elimination of gear rattle. First design steel and brass material springs as per our load. Then modelling in Creo 2.0 Athree-dimensional model of a single arc spring are optimized by modal analysis and static structural deformation using ANSYS13.00. In experimentation manufacturing steel and brass springs. Also, to find natural frequency of both the springs with the help of FFT analyser for validation of result*

Keywords- Flywheel, Dual Mass, torsional frequency, torsional vibration, modelling, Creo 2.0,Ansys 13.00, FFT analyser.

I. INTRODUCTION

1.1 Flywheel

A flywheel is an inertial energystorage device. It absorbs mechanical energy and serves as a reservoir, storing energy during the period when the supply of energy is more than the requirement and releases it during the period when the requirement of energy is more than the supply.

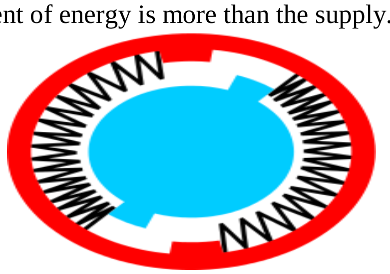

Fig. 1 Dual Mass Flywheel

Original purpose of the DMFA Dual mass flywheel or DMF is a rotating mechanical device that is used to provide continuous energy (rotational energy) in systems where the energy source is not continuous, the same way as a conventional flywheel acts, but damping any violent variation of torque or revolutions that could cause an unwanted vibration. The vibration reduction is achieved by accumulating stored energy in the two flywheel half masses over a period of time but damped by a series of strong springs, doing that at a rate that is compatible with the energy source, and then releasing that energy at a much higher rate over a relatively short time. The compact dual-mass flywheel also includes the whole clutch Piston engines do not generate a constant torque but a time-varying engine torque (t). The shape ouches torque f1Jnction depends mainly on the engine speed aping and the number of cylinders. In the engine torque i plotted over the crankshaft angle using two different levels of engine speed.

1.2 Problem Statement

Dual mass flywheel is a multiclutch device which is used to dampen Torsional vibration that occurs due to the slight twist in the crankshaft during the power stroke when the operating speed of the engine is low, vibration occurs due to the torsional resonance and this can be avoided using dual mass flywheel with arc springs. This work is carried out to study the effect of materials on the dual mass flywheel arc springs. The main aim is to decrease the torsional vibration of crank shaft and to elimination of gear rattle by changing material of the arc springs which is used in Dual mass flywheel. The effectiveness is examined Brass material spring over Steel material spring by checking natural frequency of both materials with the help of modalanalysis using ANSYS 13 &FFT analyser. A three-dimensional model of a single arc spring, are optimized by modal analysis and fatigue analysis using ANSYS 13.00.

1.3 OBJECTIVES

Development of new material springs or modification of existing material is the real challenge for most of the materials engineers. The spring will also be analysed using ANSYS software for its mechanical properties and the result will be compared with the experimental results the resulting properties would help to identify the suitable applications for this material spring. Moreover, this technique can describe a structure in terms of its natural characteristics which are the natural frequency, damping and mode shapes. Following are the objectives of the project,

1. To design Steel material spring analytically.
2. To design Brass material spring analytically.
3. To modelling of Steel spring with help of Creo 2.0
4. To modelling of Brass spring with help of Creo 2.0
5. To carry out FEA analysis of newly modelling Steel springs for finding natural frequencies and mode shapes by using ANSYS 13.00.
6. To carry out FEA analysis of newly modelling Brass springs for finding natural frequencies and mode shapes by using ANSYS 13.00.
7. To carry out FEA analysis of newly modelling Steel springs for finding deformation of at various load by using ANSYS 13.00.
8. To carry out FEA analysis of newly modelling Steel springs for finding deformation of at various load by using ANSYS 13.00.
9. To Manufacture Steel material spring at Asiatic Steel Spring Manufacture A/ p HadapsarMIDC, Pune
10. To Manufacture Brass material spring at Asiatic Steel Spring Manufacture A/ p HadapsarMIDC, Pune
11. To carry out Experimental analysis (FFT Analysis) of newly manufacture Steel springfor finding natural frequencies at Trinity College of Engg. A/ p BopdevGhat, Yewlewadi, Pisoli,Pune.
12. To carry out Experimental analysis (FFT Analysis) of newly manufacture Brass spring for finding natural frequencies at Trinity College of Engg. A/ p BopdevGhat, Yewlewadi, Pisoli,Pune

1.4 Methodology

In this paper following different methods are adopted.

A) AnalyticalMethod- In analytical method design of both material springs

1. Design Steel material spring.
2. Design Brass material spring.

B)Numerical Method – In numerical method modelling and analysis of both materials springs

1. Modeling of Steel material spring with help of Creo 2.0
2. Modeling of Brass material spring with help of Creo 2.0
3. FEA analysis of newly modelling Steel springs for finding natural frequencies and mode shapes by using ANSYS 13.00.
4. FEA analysis of newly modelling Brass springs for finding natural frequencies and mode shapes by using ANSYS 13.00
5. FEA analysis of newly modelling Steel springs for finding deformation of at various load by using ANSYS 13.00.
6. To carry out FEA analysis of newly modelling Steel springs for finding deformation of at various load by using ANSYS 13.00.

C) Experimental Method- In this method manufacturing and FFT analysis of springs

1. Manufacture Steel material spring at Asiatic Steel Spring Manufacture A/ p Hadapsar MIDC, Pune
2. Manufacture Brass material spring at Asiatic Steel Spring Manufacture A/ p Hadapsar MIDC, Pune
3. To carry out Experimental analysis (FFT Analysis) of newly manufacture Steel spring for finding natural frequencies at Trinity College of Engg. A/ p BopdevGhat, Yewlewadi, Pisoli,Pune.
4. To carry out Experimental analysis (FFT Analysis) of newly manufacture Brass spring for finding natural frequencies at Trinity College of Engg. A/ p BopdevGhat, Yewlewadi, Pisoli,Pune

II. EXPERIMENTAL WOK

1)Analytical Method- In that method Steel & Brass material springs design as per our parameters

Design of Steel Material spring-

Design helical spring for steel material as per following parameters

a) Load (W) = 250N
b) No. of Coils(n) = 15
c) Assume dia. of wire =6.40mm (Standard value from R. S. Khurmi)
d) Modulus of Rigidity of steel =80 X 10^3 MPA
e) Assume deflection of spring =30mm

Table No.1 Parameters of Steel Spring

Parameter	Value
D	51.25 mm
Ls	96 mm
Lf	130.15 mm
δ	30mm
C	8.0078
K	8.33
P	8.67mm
τ	0.58 Mpa

Design of Brass Material spring-

Design helical spring for steel material as per following parameters

a) Load (W) = 250N
b) No. of Coils(n) = 15
c) Assume dia. of wire =6.40mm (Standard value from R. S. Khurmi)
d) Modulus of Rigidity of steel =80 X 10^3 MPA
e) Take coil dia. of spring as above =51.25 mm

Table No. 2 Parameters of Brass Spring

Parameter	Value
D	**51.25mm**
δ	67.10 mm
Ls	96 mm
Lf	196.5 mm
C	8.0078
K	3.72
P	13.1 mm
τ	0.58 mpa

In Steel spring and In Brass spring induced shear stress is same so there is no matter about material change our main aim is increase the deflection that is achieved by above design

2) Numerical Analysis – In numerical analysis take modeling of steel spring and brass spring with Creo 2.0 then take analysis of both springs with ANSYS 13.00

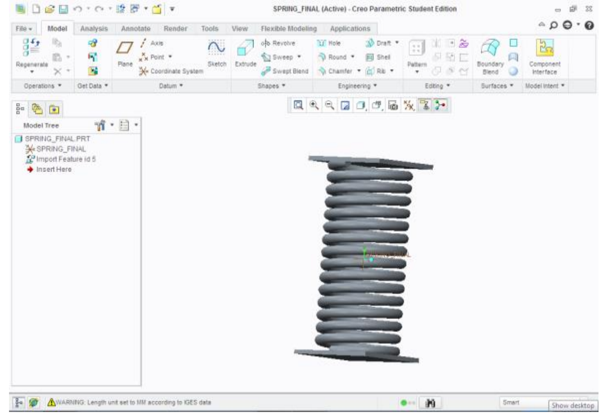

Fig. 2 Model of Steel spring With Creo 2.0

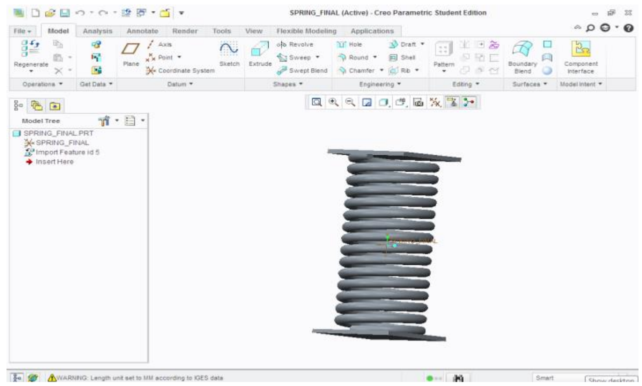

Fig.3 Model of Brass spring With Creo 2.0

Analysis of springs by ANSYS 13.00

Mode shapes for Steel spring

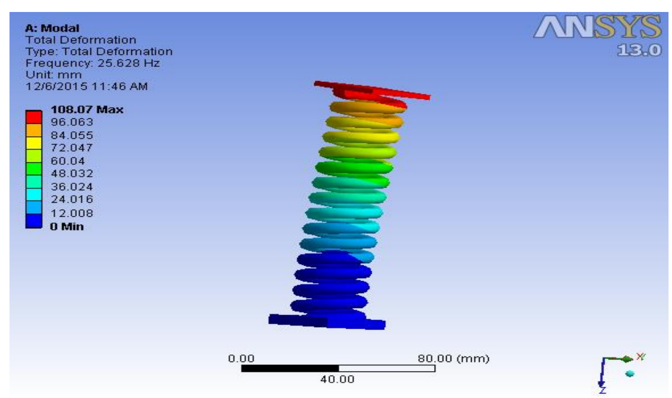

Fig.4 Mode shapes for Steel spring

Table No. 3 Natural frequencies for Steel Spring

Mode No.	Natural frequency (Hz)
1	25.628
2	115.17
3	126.27
4	145.91
5	146.6

6	343.63
7	360.59
8	381.21

Mode shapes for Brass spring

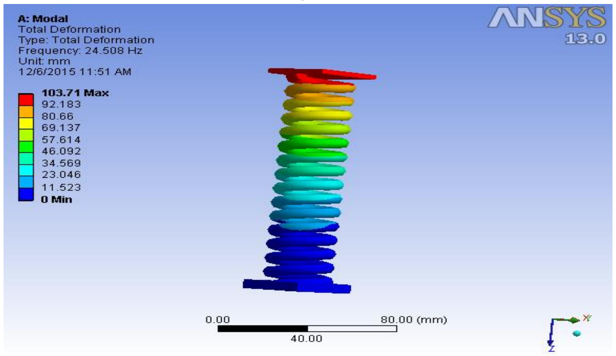

Fig.5 Natural frequencies for Brass Spring

Table No. 4 Natural frequencies for Brass Spring

Mode No.	Natural frequencies (Hz)
1	24.501
2	110.75
3	121.42
4	140.97
5	330.42
6	346.73
7	350.59
8	366.56

The result for modal analysis of springs by ANSYS gives above eight natural frequencies which are further compared to each other in result and discussion

Experimental analysis –

In Experimental analysis first manufacture steel spring and brass spring at Asiatic Steel Spring manufacturer in Hadapsar M I D C,Pune then take FFT analysis for finding natural frequency of both materials at Trinity College of Engg. A / p PisoliBopdevGhat,Pune

Fig. 6 Final Springs

Process sheet for manufacturing Steel spring and Brass Spring

Experimental Modal analysis

Modal analysis is the study of the dynamic properties of structures under vibration excitation. Modal analysis is the field of measuring and analysing the dynamic response of structures and or fluids during excitation. Examples would include measuring the vibration of a car's body when it is attached to an electromagnetic shaker, or the noise pattern in a room when excited by a loudspeaker. Modern day modal analysis systems are composed

Experimental setup

Experimental setup was prepared to carry out modal analysis. Experimental setup requires VA4Pro FFT analyser, accelerometer, impact hammer, connection cables, fixed support, nut and bolts etc.

Experimental setup for Steel spring

Fig. 7 Experimental setup for Steel spring

Table No. 5 Natural frequencies for Steel Spring

Mode No.	Natural frequency (Hz)
1	23
2	92
3	104
4	191
5	251
6	327
7	329
8	466

Experimental setup for Brass spring

Fig. 8 Experimental setup for Brass spring

Table No. 6 Natural frequencies for Brass spring

Mode No.	Natural frequencies (Hz)
1	15
2	60
3	112
4	163
5	213
6	256
7	302
8	376

With respect to above readings Compares of natural frequency of steel spring and brass spring we will discuss in result and discussion chapter.

III. RESULT & DISCUSSION

In this paper the results obtained in the ANSYS and in FFT analyser are compared to each other. The comparison is made between the Steel Spring and Brass spring. Also, the comparison in results of Steel spring and Brass spring is carried out in the sense of natural frequencies, mode shapes and deformation.

3.1 Comparison based on ANSYS results

Here the results obtained in ANSYS 13.0 for Steel Spring and Brass spring are compared in the sense of natural frequencies, mode shapes and deformations of mode shape. Graphs are also plotted to compare the Steel Spring and Brass spring. in respect to various aspect as natural frequency and deformation of mode shapes.

3.2 Comparison of natural frequency

The following Table 4.1 gives the comparison in the sense of natural frequencies at first eight modes of vibration for Steel Spring and Brass spring. It also gives decrease in frequencies and percent decrease in frequencies for Steel Spring and Brass spring at first eight modes.

3.3 Validation of ANSYS and FFT results for Steel Spring

Here comparison of ANSYS and FFT results are compared for Steel spring. Following Table 6.4 shows the ANSYS and FFT results for first eight mode numbers. Table 4.4 also shows the error and percentage error in the ANSYS and FFT results for first eight mode numbers of steel spring

Table No. 7Comparison of FEA and Experimental results for Steel Spring

Mode No	ANSYS results	FFT results	Error (Hz)	% error
1	25.628	23	2.628	11.42609
2	115.17	92	23.17	25.18478
3	126.27	104	22.27	21.41346
4	145.91	191	-45.09	-23.6073
5	146.6	251	-104.4	-41.5936
6	343.63	327	16.63	5.085627
7	360.59	329	31.59	9.601824
8	381.21	466	-84.79	-18.1953

From the Table 6 it can see that for mode 1, 6, 7, 8 ANSYS and FFT results are vary. The percentage error in ANSYS and FFT result is varies between 6 to 18.19percent. The percentage error is below 20 % and hence it validates the results obtained for Brass Spring

Table No. 7 Comparison of ANSYS and FFT results for Brass spring

Mode No	ANSYS results	FFT results	Error (Hz)	% error
1	24.508	15	9.508	63.38667
2	110.75	60	50.75	84.58333
3	121.42	112	9.42	8.410714
4	140.97	163	-22.03	-13.5153
5	330.42	213	117.42	55.12676
6	346.73	256	90.73	35.44141
7	350.59	302	48.59	16.0894
8	366.56	376	-9.44	-2.51064

From the Table 7 it can seethat for mode 3, 4, 7, 8 ANSYS and FFT results are vary. The percentage error in ANSYS and FFT result is varies between 3 to 16.08percent. The percentage error is below 30 % and hence it validates the results obtained for Brass Spring

IV. CONCLUSION

With respect to above all work following conclusion are drawn:

- **Natural Frequency** – When taking reading with numerically and experimentally it was observed that the natural frequencies of Brass spring are decreases by 1 Hz to 10 Hz of Steel spring fromfirst to eighth natural frequency. Hence there is 1- 23 % decrease in natural frequencies of Brass spring than steel spring that is effect on the shock absorbing of spring. Due to this deflection increases and more shock absorbed
- **Deformation of spring** - When conducting static structural analysis in Ansys 13.00.it is observed that the deformations of Brass spring areincreases by 10% of Steel spring fromfirst to seventh natural frequency. If deformation increases of spring then automatically shock absorbing capacity also be increased of the dual mass flywheel spring.
- **Ultimate Tensile Strength**– When comparing steel and brass we observed that of Steel spring is 450 N/mm^2 and that of Brass spring 525 N/mm^2. Ultimate Tensile Strength of Brass Spring is increased by 75 N/mm^2 than the Steel Spring. It is very beneficial to life of the spring
- **Corrosion resistant -** When comparing steel springand brass spring then it observed that brass spring is corrosion resistant material then life of spring increases and also maintenance cost decreases.
- **Weight**- Weight of flywheel is most important factor in flywheel which much affected on vehicle performance there is correlation between natural frequencies inversely proportional to the mass. Decrease in natural frequency indicates there is relative increase in weight. It is beneficial to flywheel

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