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 A three-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 vibration, modelling, Creo 2.0, Ansys 13.00, FFT analyser, Validation of ANSYS and FFT results.

1. Introduction

Flywheel

A flywheel is an inertial energy storage 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.

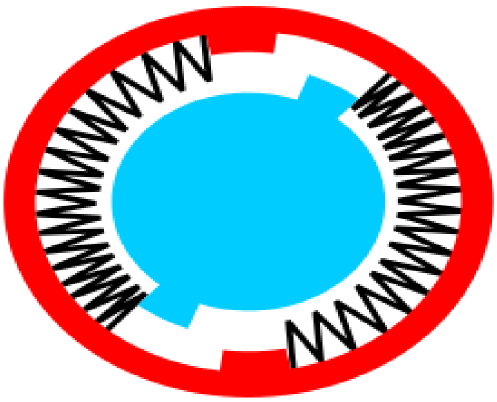

Fig. 1 Dual Mass Flywheel

Original purpose of the DMF A 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.

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 modal analysis 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.

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

Methodology

In this paper following different methods are adopted.

A) Analytical Method- 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 Bopdev Ghat, 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 Bopdev Ghat, Yewlewadi, Pisoli, Pune

Literature Survey

Dr. K. Annamalai & A. Govinda (2014) studied the theoretical and experimental dynamic behaviour of different materials for dual mass flywheel spring 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. 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. A three-dimensional model of a single arc spring, hard-soft spring combination and single mass with arc springs are optimized by modal analysis and fatigue analysis using ANSYS. 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. The vibration caused by the torsional resonance when the operating speed of the engine is low can be avoided using dual mass flywheel. This work is carried out to study the effect of arc springs on the dual mass flywheel, a three-dimensional model of a single arc spring, two arc springs with different stiffness and single mass with arc springs are optimized using ANSYS. The simulation of fatigue analysis is also performed using ANSYS.

D. G. Dighole, Prof. R.S. Shelke, Prof. Dr. S.N. Shelke (2015) studied about the rapid developments of vehicle technology over the last few decades, flywheels have been used to achieve smooth operation of machines. The early models where purely mechanical consisting of only a stone wheel attached to an axle. Nowadays, flywheels are complex constructions where energy is stored mechanically and transferred to an integrated motor/generator. The stone wheel has been replaced by a steel or composite rotor and magnetic bearings have been introduced. Today flywheels are used as supplementary UPS storage at several industries world over. Flywheels serve as kinetic energy storage and retrieval devices with the ability to deliver high output power at high rotational speeds as being one of the emerging energy storage technologies available today in various stages of development, especially in advanced technological areas, that is spacecrafts. Today, most of the research efforts are being spent on improving energy storage capability of flywheels to deliver high power transfer, lasting longer than conventional battery powered technologies. This study solely focuses on exploring the effects of dual mass flywheel geometry for improving energy storage capability to deliver high power transfer per unit mass, as compared to conventional flywheel. Dual mass flywheel also reduces the weight of the flywheel using composite materials. In this study using the two spring two mass system to produce useful vibrations which will be employed to increase the inertia of the system and thereby enable to reduce the weight of existing flywheel or increase power output using existing weight of flywheel. They concluded that there is approximately 7 to 8 % increase in power output by using the Dual mass flywheel and also observed that the Dual mass flywheel is 5 to 6 % efficient than the conventional flywheel which will also result in increasing fuel economy of the engine.

By Park, Dong hon Suwon- si, Kyunggi do (2000) [6] invented about a dual mass flywheel for a vehicle includes us a primary flywheel connected to a crank shaft of an engine a dumper housing integrally formed in a circumfertially direction of the primary flywheel. A secondary flywheel connected to an input shaft of a transmission and rotating mounted on a hub of primary flywheel. Driven fingers integrally formed the second flywheel and insert the vertically in to the dumper housing to be forced by the dumper spring. The dumper springs compresses two spring sets symmetrically disposed within the dumper housing .one end of each dumper springs being driven by the stoppers which are integrally formed on primary flywheel. While the other end of springs drives the driven finger of the secondary fly wheel. The primary and secondary flywheels are integrally provided which projections for preventing the dumper spring from excessively compressed & damaged. The dumper spring compressed a plurality of springs. Each having difference springs coefficients and the dumper springs are supported by a plurality of a sliding guide or blocks in that way torsional vibrations of cranck shaft get reduced with the help of Dual Mass Flywheel

Ulf Shaper, Oliver Sawodny, Tobias Mahl and UtiBlessing (2009) [5] that research about -The Dual Mass Flywheel (DMF) is primarily used for dampening of oscillations in automotive power trains and to prevent gearbox rattling. TWs paper explains the DMF mechanics along with its application and components. Afterwards a detailed abs-initio model of the DMF dynamics is presented. This mainly includes a model for the two arc springs in the DMF and their friction behaviour. Both centrifugal effects and redirection forces act racially on the arc spring which induces friction. A numerical simulation of the DMF model is compared to measurements for model validation. Finally, the observe ability of the engine torque using the DMF is discussed. For this purpose, a linear torque observer is proposed and evaluated. In today's world power train control sits acclimates torque information to perform various tasks. These tasks include for example the clutch acnl3tion in automated manual transmissions and dual-clutch transmissions as well as the control of electric motors in hybrid power trains. Indirect torque estimation is needed because the direct measurement of the transmuted torque using strain gages cannot be done in volume production cars for economic reasons. One source for power train torque estimation is the engine itself. However, the torque estimation provided by the internal combustion engine is based on complex thermodynamic models. These engine models tend not to be reliable in all situations. Critical a picture indeed the accuracy of the lobo charger models and the influence of exhaust gas recirculation on combustion calculation.

By Rudolf Glassner (2013) [6] studied about Dual Mass flywheel of driver train of vehicle includes a primary flywheel mass, Secondary flywheel mass & coupling device. The coupling device include at least two pivot levers associated with secondary flywheel mass with inter act with a control profile formed on primary flywheel mass. The pivot levers are pre tensional against control profile in a radial direction by the elastic element. a control segment of elastic element is disposed radially inside control profile. An object of the present invention is to provide a dual mass flywheel having coupling device which has fewer speed dependent coupling characteristics .In the Dual mass flywheel in accordance with the invention the centrifugal force acting on elastic elements in operation is minimized in that elastic elements are more closely to axis of rotation of dual mass flywheel than previously usual If the flywheel is too light the motorcycle requires more effort to start, idles badly, and is prone to stalling. Weight is not the important factor here, but inertia. Inertia is stored energy, and is not directly proportional to flywheel weight. It's possible to have a light flywheel with much more. Any power the motor develops must accelerate the flywheels before leaving the sprocket shaft, and any used in bringing the flywheel up to speed is not available at the rear wheel

Li Quan Song, Li Ping Zeng, Shu Ping Zhang, Jian Dong Zhou Hong En Niu (2014) was develops new structure of new structure of dual mass flywheel (DMF) with continuously variable stiffness is proposed based on compensation principle in order to release the impact produced by the step changes of stiffness. By theoretical calculation and experiments, the proposed structure and design theory involved are proved to be feasible for reducing the torsional vibration of the power transmission system for automobiles with large-power and high-torque engines. The natural characteristics of the vehicle power transmission system carrying the DMF are analysed to investigate the influence of torsional stiffness on the first-order and the second-order resonance speeds. The results show that this new DMF can lower the idle speed of the engine, realize high counter torque at a large torsional angle, and avoid the impact due to the abrupt changes of stiffness. An inertia balance mechanism is proposed to eliminate the inertia forces produced by moving parts of the compensation device, which can successfully put the torque compensation theory into engineering practice. By adding a compensation device, a new DMF with continuously variable stiffness is presented to release the impact produced by the step changes of stiffness. This new DMF can avoid impact and noise more effectively. By adding a compensation device, a new DMF with continuously variable stiffness is presented to release the impact produced by the step changes of stiffness.

Sagar N Khurd, Prasad P Kulkarni, Samir D Katekar (2015) study represents new approach to design helical coil spring by using workbench. Response surface modelling and analysis of helical spring by considering Translational invariance have been carried out. In previous paper we had considered longitudinal invariance. Design parameters are wire diameter, coil diameter, height, number of turns elastic modulus in X and Y direction, force. Simple equation is proposed which gives value of compressive stress of helical coil spring by carrying out regression analysis done by M S excels, it is observed that force and material property are significant parameters which affect compressive stress because their P value is 1. Relationship among design parameters and compressive stress has been obtained. In this analysis it is observed that coil diameter increases stress on the spring decreases. It is observed that force and material property are significant parameters which affect compressive stress.

C. Madan Mohan Reddy, D. Ravindra Naik, Dr. M. Lakshmi Kantha Reddy (2014) studied about present work is carried out on modeling, analysis and testing of suspension spring is to replace the existed steel helical spring used in popular two-wheeler vehicle. The stress and deflections of the helical spring is going to be reduced by using the new material. The comparative study is carried out between existed spring and new material spring. Static analysis determines the stress and deflections of the helical compression spring in finite element analysis. The testing proto type is used to test the spring under different loading conditions. Finite element analysis methods (FEA) are the methods of finding approximate solutions to a physical problem defined in a finite region or domain. FEA is a mathematical tool for solving engineering problems. In these the finite element analysis values are compared to the experimental values. A typical two-wheeler suspension spring is chosen for study. The modeling of spring is developed on pro/E 5.0 analysis is carried out on Ansys 14. They conclude that the comparative study has been carried out in between the theoretical values to the experimental values and the and the analytical values. The maximum shear stress of chrome vanadium steel spring has 13-17% less with compare to hard drawn steel spring.

` **Prince Jerome Christopher J, Pavendhan R. (2010)** studied about vehicles problem happens while driving on bumping road condition. The objective of this project is to design and analyse the performance of Shock absorber by varying the wire diameter of the coil spring. The Shock absorber which is one of the Suspension systems is designed mechanically to handle shock impulse and dissipate kinetic energy. It reduces the amplitude of disturbances leading to increase in comfort and improved ride quality. The spring is compressed quickly when the wheel strikes the bump. The compressed spring rebound to its normal dimension or normal loaded length which causes the body to be lifted. The spring goes down below its normal height when the weight of the vehicle pushes the spring down. This, in turn, causes the spring to rebound again. The spring bouncing process occurs over and over every less each time, until the up-and-down movement finally stops. The vehicle handling becomes very difficult and leads to uncomfortable ride when bouncing is allowed uncontrolled. Hence, the designing of spring in a suspension system is very crucial. The analysis is done by considering bike mass, loads, and no of persons seated on bike. Comparison is done by varying the wire diameter of the coil spring to verify the best dimension for the spring in shock absorber. Modeling and Analysis is done using Pro/ENGINEER and ANSYS respectively. They have designed a Shock Absorber used in 160 cc bike and we have modelled it using 3D parametric software called Pro/Engineer. The shock absorber design is modified by reducing the diameter and stress analysis is performed. The stress value is lesser in our designed spring than in original which adds an advantage to our design. By comparing the results in the table, we could analyse that our modified spring has reduced in weight and it is safe.

Mehdi Bakhshesh, and Majid Bakhshesh (2012) both studied about springs that can reserve high level of potential energy, have undeniable role in industries. Helical spring is the most common element that has been used in car suspension system. In this research, steel helical spring related to light vehicle suspension system under the effect of a uniform loading has been studied and finite element analysis has been compared with analytical solution. Afterwards, steel spring has been replaced by three different composite helical springs including E-glass/Epoxy, Carbon/Epoxy and Kevlar/Epoxy. Spring weight, maximum stress and deflection have been compared with steel helical spring and factors of safety under the effect of applied loads have been calculated. It has been shown that spring optimization by material spring changing causes reduction of spring weight and maximum stress considerably. In any case, with changing fibre angle relative to spring axial, composite spring properties have been investigated & concluded that a helical steel spring has been replaced by three different composite helical springs. Numerical results have been compared with theoretical results and found to be in good agreement. Compared to steel spring, the composite helical spring has been found to have lesser stress and has the most value when fibre position has been considered to be in direction of loading. Weight of spring has been reduced and has been shown that changing percentage of fibre, especially at Carbon/Epoxy composite, does not affect spring weight. Longitudinal displacement in composite helical spring is more than that of steel helical spring and has the least value when fibre position has been considered to be in direction of loading. The most safety factor is related to case that fibre position has been considered to be perpendicular to loading and it is for Carbon/Epoxy composite helical spring.

Pavan Kumar AV, Vinayaka N, Dr P B Shetty, Dr. Kiran Aithal S, Gowtham V studied about that the Helical Compression spring has been designed in such a way that when the vehicle travels over the spring, the spring takes the maximum load of 200 kg and the rest is taken by the ground. For this purpose, the spring is analysed for the fatigue loads and has been optimized for the selection of material, wire diameter, carbon percentage and other governing parameters & concluded that as the diameter of spring increases, Ultimate Tensile Strength increases. As the carbon percentage increases, the Ultimate Tensile Strength increases, but flexibility decreases. As the diameter increases, factor of safety increases. As the carbon percentage increases, the factor of safety graph shifts up with respect to the previous grades. As the carbon spring is oil hardened, the strength increases and the factor of safety curve shifts up.

N. N. Suryawanshi1, Prof. D. P. Bhaskar (2015) studied about Dual Mass Flywheel (DMF) is primarily used for dampening of oscillations in automotive power trains and to prevent gearbox rattling. We explained detailed initial model of the DMF dynamics is presented. This mainly includes the two arc springs and two masses in the DMF and their behaviour. An experimental the DMF model is compared to convention flywheel. Finally, the observation of the engine torque using the DMF is discussed. For this purpose, the DMF is manufactured and done experiment or testing to see the results. And then results are comparing with the conventional flywheel &both concluded that there is approximately 10 % increase in power output by using the Dual mass flywheel.

Saurabh Singh (2012) studied about demonstrates the feasibility of adopting composite material for design of helical coil suspension system. In this paper the combination of steel and composite material is used in place of conventional steel only. The composite material used in this analysis is Glass Fiber/Epoxy. The cause of implementing combination of steel and composite material was because of the low stiffness of single composite spring, which limits its application to light weight vehicle only. And conclude that that combination of conventional steel and composite material can increase the stiffness; which is the major requirement however the ever-demanding need of weight reduction of vehicles will be satisfied by employing this method. The weight reduction in this combination of material

Demin Chena, Yueyin Ma, Wei Sun, Xiaolin Guo, Xaofei Shi (2011) studied about in order to reduce torsion vibration of automotive powertrain, angular stiffness formula of arc helix spring was built according to the performance parameter of a C-grade car. Based on the expression, a method of optimization design about arc helix spring is proposed with the variable radian. A new Dual Mass Flywheel (DMF) with 6 arc helix springs is designed. The torsion vibration simulation model of automotive power train is established by MSc. Easy and the system is analysed. Further, the experiment is made and proves that the design of DMF can satisfy the use of the car & they concluded that angular stiffness formula of arch helix spring is calculated; a new design optimization method of DMF is proposed with radian as the main variables. The DMF of six arch helix springs is designed. The torsion vibration model of a C-Class car is built by Msc.Easy5, and the vibration reduction effect of DMF designed is simulated. Finally, the experiment on the DMF is carried out and results show that it meets design requirements. This method given in the paper can be used to select the appropriate arc helix springs for DMF to avoid resonance between the transmission and engine. It makes the DMF better match with the vehicle's transmission system and access to the best effect of reducing vibration and noise. Therefore, it is quite important to improve vehicle comfort, the transmission efficiency and prolong the transmission life.

By Alaster John Young (2000) [6]explained about a twin flywheel comprising first and second co axially arranged flywheel masses which are mounted for limited angular rotation relative to the each other .The flywheel masses are inter connected at least one linkage arrangement comprising a multi-link linkage having two or more circumfertially spaced main links pivotally mounted on second flywheel masses with the circumfertially adjust pair of main links inter connected by extending connected linkage and anchor link which connect to the multi linkage with first flywheel mass .Relative rotation of flywheel mass causes multi-link linkage which connect to the second flywheel mass by anchor link , so that when twin mass is rotating ,relative rotation of flywheel masses resisted by centrifugal forces acting on linkage . Any particular link may in the form of unitary link in the form of parallel pair's plates. Associated with one or more links or pivots acting between flywheel masses there may be controlling means to control the relative rotation of flywheel masses

2. METHDOLOGIES

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

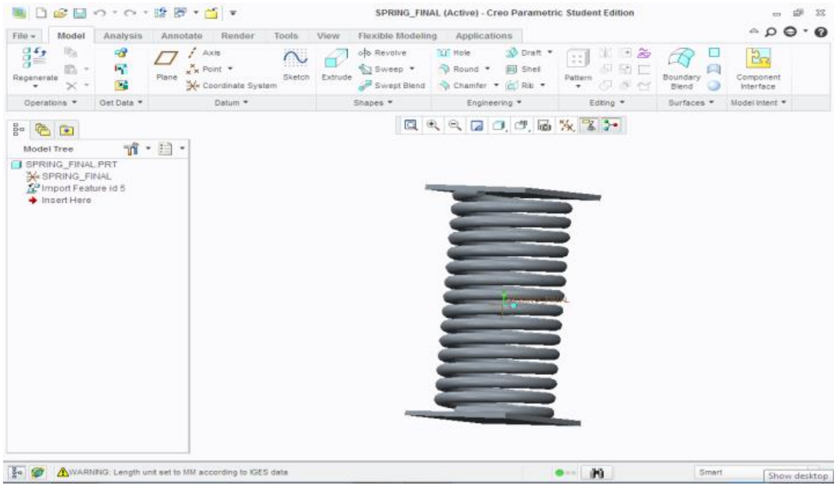

Fig. 2 Model of Steel spring With Creo 2.0

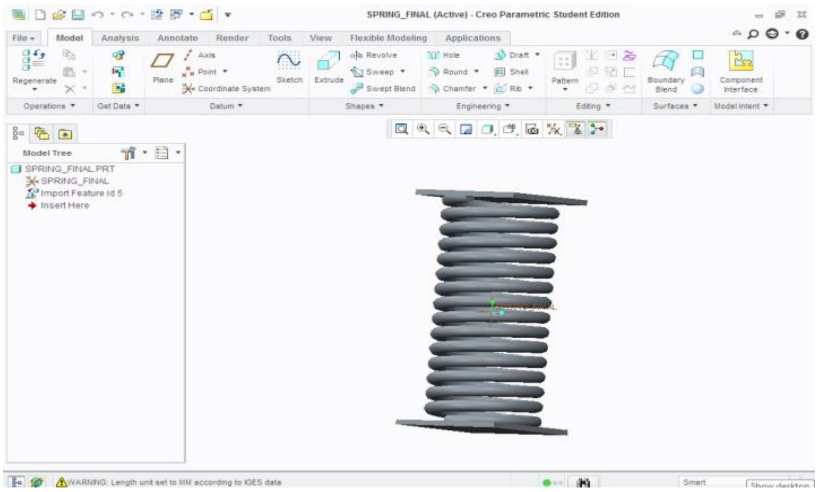

Fig.3 Model of Brass spring With Creo 2.0

Analysis of springs by ANSYS 13.00

Mode shapes for Steel spring

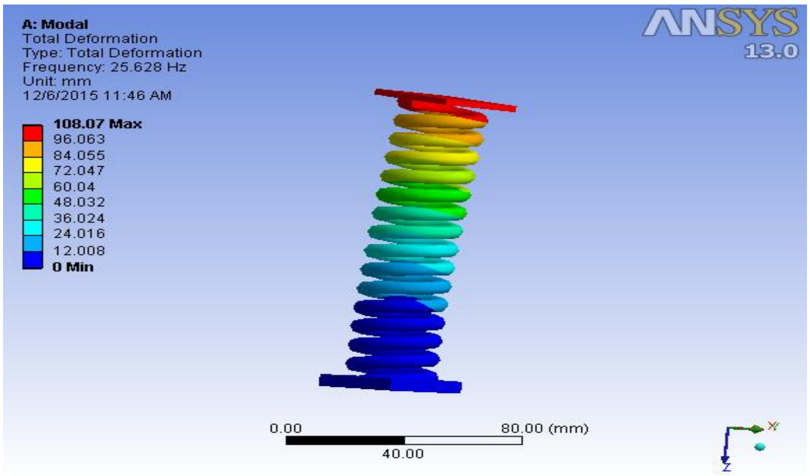

Fig.4 Mode shapes for Steel spring

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

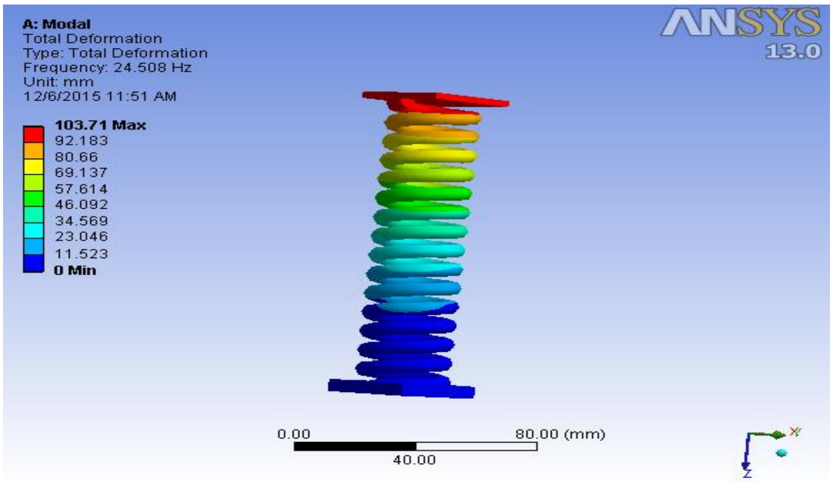

Fig.5 Natural frequencies for Brass Spring

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 Pisoli Bopdev Ghat, 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.

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.

2.1.1 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.

2.1.2 Comparison of natural frequency

The following Table No. 6 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.

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. 6 Comparison 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 see that 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

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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