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Shaker based Operating Deflection Shape(ODS) Testing of Two-Wheeler Chassis

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Abstract: Chassis is the main carriage system of vehicle. Vibration occurs in chassis due to internally generated forces, unbalances and external loads. Understanding any structural vibration problem is to define its modes of vibration. Each mode is defined by natural frequency, modal damping and mode shape. ODS testing is done for frame numerically using ANSYS. Steel chassis analysis is done both numerically and experimentally using Shaker, Data signal analyzerand ME'ScopeVES.

Key words: Two wheeler chassis frame, Finite Element, ODS testing, ANSYS, Data signal analyzer and ME'ScopeVES.

I. INTRODUCTION

Chassis serves as a skeleton upon which gear box and engine are mounted. It supports for suspension system, a collection of spring and shock absorbers. Motorcycle chassis frame are usually made of steel, aluminum or an alloy. Chassis take lot of vibrations from engine and other external forces, due to this the ride comfort of the vehicle decreases and also the performance of vehicle reduces. Chassis are usually hollow.

Commonly used techniques for vibration testing of chassis are modal analysis and ODS(Operation Deflection Shape). ODS has some advantages over Modal analysis, so ODS test is suitable for getting accurate results. ODS is a vibration testing and analysis procedure that is capable of producing animations of the deformation characteristics of a vibrating mechanical system. ODS testing provides the deformation shape of a structure in response to the forces that are applied to the structure during its operation. ODS is a combination of the forcing function acting on the structure and the dynamic properties of the structure. ODS test is suitable for getting accurate answers. ODS analysis can be divided into three types, they are Time ODS, Spectral ODS & Run-up/down ODS. In this experiment, time ODS is used.

Shaker is the instrument used to produce vibrations of required quantity. Shakers excite the structure through a narrow rod. Modal shakers are used for experiments. Force outputs from 30N to 250N. Tunable suspension to produce peak force at low resonant frequencies.

Description of two wheeler chassis

The two wheeler chassis is made up of steel and is made from tubular structures of steel pipes. The complete structure of chassis is completed by welding the parts. The tubes are of dimensions 22.5mm with thickness of 2mm. The two wheeler chassis is shown in figure 1. The engine is mounted at the lower part of chassis, the testing is done at the same place.

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Figure 1. Two wheeler chassis

II. RELATED WORK

Brian J. Schwarz et al. [1] explained that ODS can be measured directly by relatively simple means. They provide very useful information for understanding and evaluating the absolute dynamic behavior of a structure. All vibration is a combination of both forced and resonant vibration. Forced vibration can be due to, internally generated forces, Unbalances, External loads, ambient excitation. An operating deflection shape contains the overall vibration for two or more DOFs on a machine or structure. That is, the ODS contains both forced and resonant vibration components.Robert J Sayer[2] explained that, ODS is a vibration testing and analysis procedure, is capable of producing animations of a vibrating mechanical system. Operating deflection shape (ODS) analysis is usually considered an advanced vibration analysis tool, is a rather simple test and analysis procedure. ODS can provide valuable insight into the vibrational response of structural-mechanical systems. Maki.M.Onari et al.[3]explained that, ODS is a powerful tool to understand most of the vibration problems. In most of the cases, the ODS analysis provides enough information to identify and solve the problem.Dr.R.Rajappan et al. [4] proposed static and modal analysis of truck chassis using FEA. Truck chassis is a major component in a vehicle. In truck chassis different type of failures occur due to static and dynamic loading condition. In this work static and dynamic load characteristics are analyzed using FE model Identifying location of high stress area, analyzing vibration, natural frequency and mode shape by using finite element method.Mark H. Richardson [5], Answered the question, "Is it a mode shape, or an operating deflection shape?" is probably asked more often than any other when testing structures, especially when attempting to identify their resonant or modal properties. Review of literature [1-5] on study of chassis revealed that research efforts are concentrated on analytical method of finding out vibration characteristics and not much tested with experimental setup. It also explains the different type of testing methods and their procedures to conduct the test in understanding way. We determine the dynamic mode shape of the chassis by ODS testing and to study behavior of chassis at different mode shapes and frequencies. Thus, the main aim of the research is to investigate the dynamic performance of two wheeler chassis analytical and experimental using FEA and ME'ScopeVES.

III. GEOMETRICAL MODELLING

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CAD is mainly used for detailed engineering of 3d models of physical components.In this study the hero Honda two wheeler chassis frame dimensions are taken from model, with respect to those dimensions geometrical models were created in Creo 2.0, CAD software. The 3D CAD model is shown in figure 2.

Figure 2. 3D CAD Model of Two wheeler chassis

IV. FINITE ELEMENT ANALYSIS:

Harmonic analysis using Finite Element Method (FEM) can be used to determine natural frequencies and mode shapes. In this study, harmonic analysis has been accomplished by the commercial finite element packaged ANSYS. After constructing finite element model of chassis and appropriate meshing with shell elements, model has been analyzed and first 6 frequencies that play important role in dynamic behavior of chassis, have been expanded.

Motorcycle frame are made of steel, aluminum or an alloy. In numerical analysis it is tested for Steel alloy. Its material properties are given below.

Material: Alloy Steel
Young's Modulus: 1.90E+11 N/mm^2
Poison's ratio: 0.29
Density: 7680 Kg/m^3

MESH GENERATION

The model was meshed using tetrahedron elements with elemental size of 5mm. Fine mesh was required in order to improve solution accuracy. The meshed pattern of the model is as shown in figure 3.Shell element has been used for analysis. Thiselement hasbetter and more disciplined meshing in comparison with other elements and has the capability of gaining more accurate results.

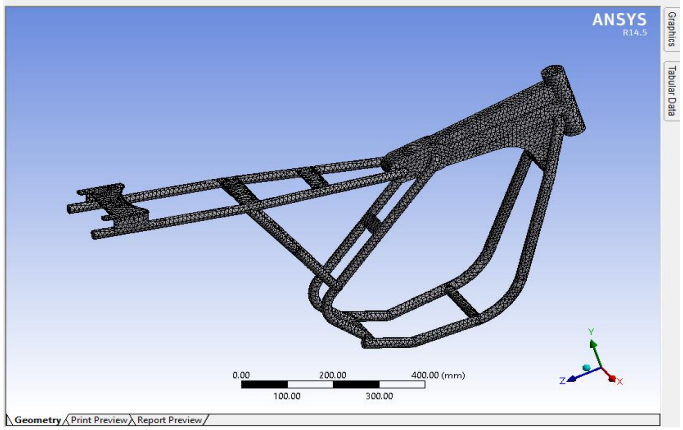

Figure 3. Mesh generation

BOUNDARY CONDITIONS

Harmonic analysis has been performed after creating the chassis finite element model and meshing in free-free state and with no constraints. The results have been calculated for the first 12 frequency modes. In this analysis we have made use of subspace method in ANSYS. Since chassis has no constraints; the first 6 frequency modes are vanished.

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V. EXPERIMENTAL ANALYSIS

Steel chassis analysis is done experimentally using data signal analyzer and ME'ScopeVES.Vibrations are induced to chassis through Shaker and measured it by accelerometer, which is connected to DSA.ME'ScopeVESsoftware is used to convert those signal inputs toresults. Frequency and mode shapes are found out. The experimental set up and ME'ScopeVES model is shown in figure 4 and figure 5 respectively.

Figure 4

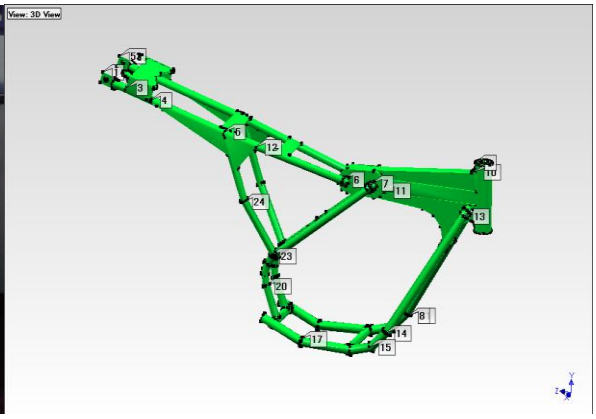

Figure 5

VI. RESULTS AND DISCUSSION

The study proposes a critical comparison of results obtained in terms of dynamic characteristic of chassis frame made of alloy steel. It has been observed that due to various approximations made in finite element model the predicted values of the dynamic characteristics of chassis quite often differs from that of the actual structure. Experimented results from data signal analyzer and ME scope is one of the accurate methods of testing.

Table I
Experimental Results

Mode no	Frequency in Hz
1	35
2	70
3	133
4	164
5	197.5
6	231.5
7	305

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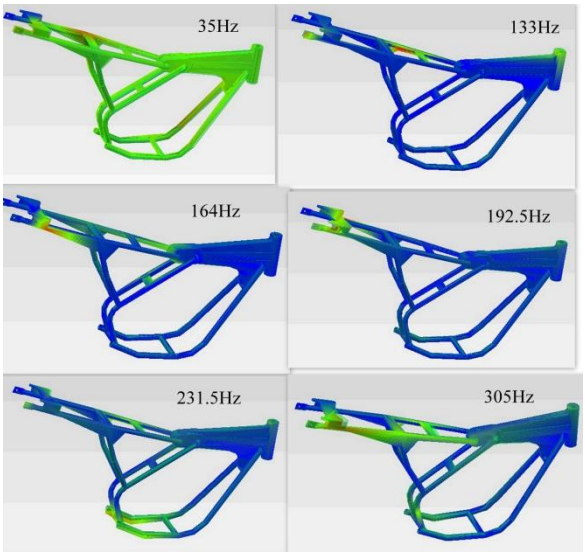

Figure 6. Experimental mode shapes

The complete details of all the 39 points frequency results are as shown in Fig.7.

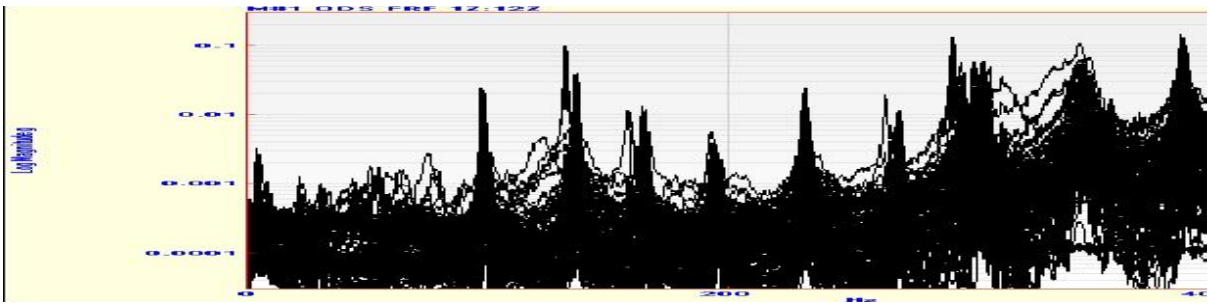

Figure 7. Frequency results of all 39 points of two wheeler chassis

It has been observed that due to various approximations made in finite element model the predicted values of the dynamic characteristics of two wheeler chassis quite often differs from that of the actual structure. Experimented results from DSA and ME scope is one of the accurate methods of testing.Table II gives the results obtained from the analytical method.

Table II

FEA Results

Mode No	Frequency in Hz
1	44.286
2	88.571
3	132.86
4	177.14
5	221.43
6	265.71
7	309.84

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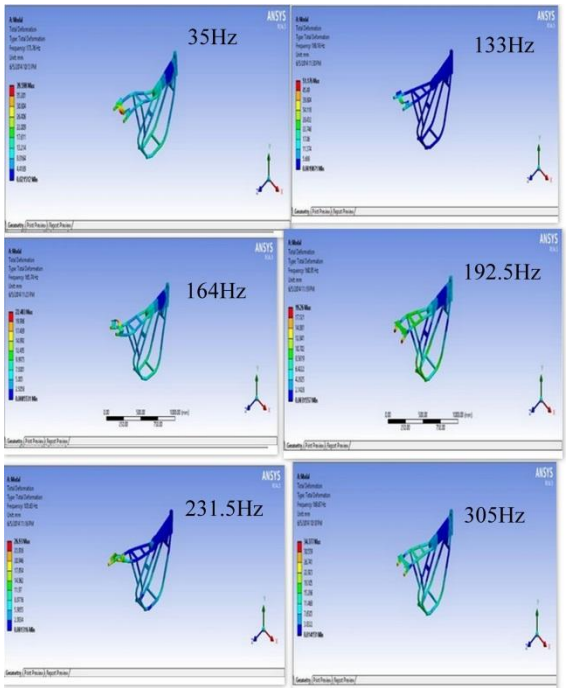
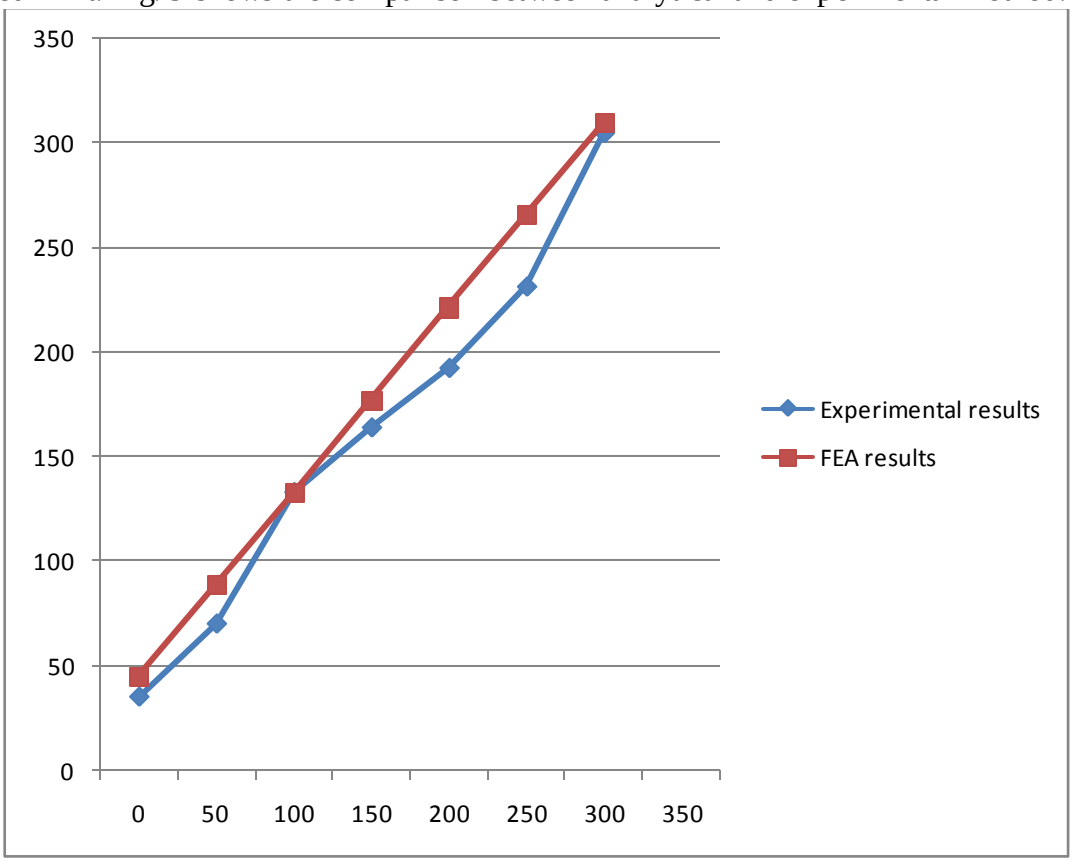


Figure 8. FEA mode shapes

Frequencies obtained from the experimental and FEA methods are compared and the error is within the desired limit. Fig. 9 shows the comparison between analytical and experimental method.



VII. CONCLUSION

- The paper has looked into the determination of the dynamic characteristic of two wheeler chassis the natural frequency and mode shapes.
- The vibration of chassis includes torsion, lateral bending and vertical bending in different modes.

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- Since FE and experimental tests are in co-relation, for new product development FEM approach can be used to reduce design time, cycle time, testing time and its associated costs.
- The work presented in paper is in early phases and it's important to note these results will strongly demand more detailed analysis for future projects.

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