A REVIEW ON DYNAMIC ANALYSIS OF MACHINE STRUCTURE

Mahmood Gaznavi[1], Anil Kumar G[2], Satheesh.J [3], Madhusudhan T[4]

[1] *M.Tech student, Mechanical Department, Machine Design, SJBIT, Bengaluru, India*
[2] *Associate Professor Mechanical Department, SJBIT, Bengaluru, India.*
[3] *Professor Mechanical Department, SJBIT, Bengaluru, India*
[4]*Professor Mechanical Department, SJBIT, Bengaluru, India*

---***---

Abstract - ***Dynamic analysis of machine structure is necessary to ensure not only the comfort of the users, but ensure good conditions for the operation of equipment supported. With increase in the rapid development of changing technology there is a need for proper optimization to increase the efficiency& job accuracy. The objective of dynamic analysis is to analyze the behavior of a structure, when subjected to forcing function under resonance condition. This paper outlines the dynamic analysis of machine structure under different natural frequencies & mode shape by using FEM packages. Vibration in a machine structure due to unbalancing of masses is a major challenge which can be analyzed & overcome.***

Key Words: *Dynamic analysis, vibration, modal analysis, FEM packages, frequency & mode shape.*

1. INTRODUCTION

Dynamics of structures studies movements of bodies caused by forces applied to them and also the forces that cause movements in structures. Structural Dynamics testing and analysis contributes to progress in many industries, including aerospace, auto making, manufacturing, wood and paper Production, power generation, defense, consumer electronics, telecommunications and transportation. The adequate dynamic analysis of structures implies the creation of models that allow converting a pre-established entity, in a complex way, into something that the current resources can understand and model.

1.1 Vibration

The term vibration describes repetitive motion that can be measured and observed in a structure. Unwanted vibration can cause fatigue or degrade the performance of the structure. Therefore it is desirable to eliminate or reduce the effects of vibration. In other cases, vibration is unavoidable or even desirable. In this case, the goal may be to understand the effect on the structure, or to control or modify the vibration, or to isolate it from the structure and minimize structural response.

Free vibration is the natural response of a structure to some impact or displacement. The response is completely determined by the properties of the structure, and its vibration can be understood by examining the structure's mechanical properties. For example, when you pluck a string of a guitar, it vibrates at the tuned frequency and generates the desired sound. The frequency of the tone is a function of the tension in the string and is not related to the plucking technique.

Forced vibration is the response of a structure to a repetitive forcing function that causes the structure to vibrate at the frequency of the excitation. For example, the rear view mirror on a car will always vibrate at the frequency associated with the engine's RPMs. In forced vibration, there is a relationship between the amplitude of the forcing function and the corresponding vibration level. The relationship is dictated by the properties of the structure.

1.2 Dynamic Analysis

Dynamic analysis can be used to determine the vibration characteristics (natural frequencies and mode shapes) of a structure or a machine component while it is being designed. It also can be starting point for another, more detailed, dynamic analysis, such as a transient analysis, a harmonic analysis, or a spectrum analysis. Dynamic analysis is the study of the dynamic properties of structures under vibrational excitation.

2. LITERATURE REVIEW

Rafael Marin Ferro [1] conducted a performance check of support frame structure to estimate the dynamic loads caused by rotating equipment on supports using computational models with strap software. The paper concluded that fully rigid structures is suitable for dynamic structure point of view

Jayarajan P. [2] studies revealed the dynamic analysis of turbo-generator machine foundations. This paper outlines the procedure for finite element modeling of foundation structure by considering both free vibration analysis & harmonic forced analysis. This paper concluded various challenges relater to modeling of structure, machine & soil for dynamic analysis.

Zissimos.P Mourelatos [3] demonstrated structural dynamic analysis of crankshaft system model of internal combustion engines. In this paper author uses two-level dynamic sub structuring technique to analyze the dynamic response based on FEM model. Reynolds's equation& load- dependent Ritz vector method has been used for two level technique. The paper concluded the behavior of machine structure with respect to various frequency graph. Inertia reduction with the effect of elastomers damping.

P.S Shenoy [4] explained detailed load analysis under service loading conditions for a typical connecting rod, followed by quasi-dynamic finite element analysis (FEA) to capture stress variations over a cycle of operation. In this paper, comparison of stresses using static FEA & quasi dynamic FEA. Static analysis of a connecting rod which can yield unrealistic stresses, whereas quasi-dynamic analysis provides more accurate better suited for fatigue design and optimization analysis of this high volume production component. The mean load changes with length of connecting rod as well as with change in engine speed.

H.Hirani [5] demonstrated damping coefficients of an engine bearing over a load cycle. Dynamic engine loads technique is used to determine the shaft cycle limit. This paper theoretical model is used, which is based on short & long bearings. This paper outline the results based on stiffness & damping coefficient validation which gives realistic results compared to thermal analysis.

Pravin A Renuke [6]
The paper highlighted the vibrational characteristics of the optimization of car chassis including the natural frequencies and mode shapes. The author considered modal analysis using FEM to carry out the demonstration. He concluded that decreases the chassis length, can increase the chassis stiffness which can prevent resonance phenomenon and unusual chassis vibration and place the natural frequencies in natural range.

B.V Subrahmanyam [7] outlined the static & dynamic analysis of machine tool structure to prevent the gradual failure of machine. The author uses FEA modelling & modal analysis method to demonstrate the challenges. Lathe machine, shaper machine, milling machine has been used in this paper. It is shown that Von Misses stress observed is high for lathe. In all machines, the stresses are high along x-direction, is a direction transverse to the longitudinal axis. The deflection is observed to *be* more predominant in milling machine.

Namdev .A. Patel [8] studied the vibrational analysis of CI engine with the help of FFT analyzer. The paper is framed as engine rigid body modeling, engine vibrations in detail and at last some experimental work performed on a single cylinder diesel engine to measure vibrations using FFT spectrum analyzer. The author concluded that magnitude of Vibration depends upon selection of axis of engine for acquisition of signatures. From analysis we get to know vibrations are greater in Y direction as compared with X and Z direction. Magnitude of vibration depends upon engine speed. As the speed of engine decreases the vibration acceleration amplitude also decreases in Y direction but increases in X and Z direction. With increase in load on engine the fuel rate increases, vibrations in Y direction decreases but increases in X and Z direction.

S.C Jaisawal [9] studied multi body dynamic analysis & simulation of engine model. This paper has an overview of the model with a new running speed which generate the challenges of stress in the connecting rod. It is concluded that there is no stress developed in any component of the engine at a particular given speed of 4mm/s. So the model is successful for that speed or less. Beyond this the stresses will develop and the model will fail.

Sondipon Adhikari [10] demonstrated dynamic analysis of framed structure with statistical uncertainties. The analysis is based on the assembly of element stochastic dynamic stiffness matrices. The solution involves inversion of the global dynamic stiffness matrix, which, in this case, turns out to be a complex-valued symmetric random matrix.

Jovan Validic [11] studied on dynamic behavior of the loading lifting mechanisms. In this paper, the step of establishing the correct dynamic model and corresponding equations is proposed. It's on the analysis of the relevant influences, such as variation of the rope free length, slipping of the elastic rope over the drum or pulley and damping due to the rope internal friction. The concluded talk on this dynamic model for elevator driving mechanism provides the analysis of relevant parameters and a base for the assessment of lifting process stability through the critical velocity level.

Piyush K. Bhandari [12] described dynamic analysis of machine foundation. The two parameters named as limiting amplitude and operating frequency of a machine to be considered in analysis of machine foundation. The author has taken Elastic half space analogy method with embedment coefficients into considerations which can be used for coupled modes of vibration to get the natural frequencies and forcing function. The paper concluded the cause of amplitudes uncoupled vibrations in sliding as well as in rocking modes are less as compared to coupled vibrations. At higher depth of embedment the total vertical and horizontal vibration response decreases. The natural frequency of foundation increases with increase in depth of embedment of foundation.

Darina Hroncova [13] outlined the dynamic analysis of shaping machine mechanisms. Mathematical model has been used for mechanisms and was completed using MSC Adams. Program MSC Adams/View makes it easy to analyze complex mechanical systems with multiple degrees of freedom.

T. Raja Santosh Kumar [14] outlined the design and dynamic analysis of flywheel. Modeling software pro/e has been used & analyzed at different time interval with different loading conditions for power 20kw and speed at 400 rpm to 410 rpm. The author aimed is to reduction of weight. The wheel-shaped structure contributes to decrease stress concentration. The wheel-shaped structure is advantageous to get good performance and reduce the cost.

Giacomo Bianchi [15] highlighted the use of damping in machine tools to suppress the vibration during dynamic analysis. Transferring energy dissipation mechanisms into numerical structural models. It is concluded that at multiple point which allows to investigate the complex interaction, in a machine tool, between structural dynamics, motion control and friction forces.

Anayet U.Patwari [16] presented a study on dynamic modal analysis of vertical machining center components. The main objective was to deal with the results of different mode shape of components. Modeling has been done by Catia & analysis performed in abacus. Closeness of results was observed between natural frequencies of finite element modeling and model testing. The concluded results shown that the suitable frequency ranges for end milling will be up to 12000 Hz.

3. CONCLUSIONS

- Dynamic analysis shows the closeness of results between frequency & forcing function.
- Dynamic analysis provides a goods efficiency& reduce the costs through optimization of the structures.
- Material design should be below the critical stress of the materials.
- FFT analysis is a better technique to get the signature of frequency response of dynamic analysis.
- Unwanted vibration can be suppressed with the use of damping system & balancing of masses.
- Quasi static dynamic analysis provides more accurate better suited for fatigue design and optimization analysis of this high volume production component.
- The better design of the material can reduce the stress concentration.

4. REFERENCES

[1] Rafael Marin Ferro, Walnó Graça rio Ferreira & Adenilcia Fernanda Grobério Calenzani Dynamic Analysis of Support Frame Structures of Rotating Machinery Global Journal of Researches in Engineering: e Civil and Structural Engineering Volume 14 Issue 5 Version 1.0 Year 2014

[2] Jayarajan P.,Kouzer K.M. dynamic Analysis of Turbo-generator Machine Foundations, Journal of Civil Engineering and Environmental Technology Volume 1, Number 4; August, 2014.

[3] Zissimos .P. Movrelatos, A crankshaft system model for structural dynamic analysis of internal combustion engines 14 June 2002.

[4] P S Shenoy and A Fatemi Dynamic analysis of loads and stresses in connecting rods Department of Mechanical, Industrial, and Manufacturing Engineering, The University of Toledo, Toledo, Ohio, USA, 6 Feb 2016

[5] H. Hirani, K. Athre and S. Biswa Sb dynamics analysis of engineering bearings International Journal of Rotating Machinery1999, Vol. 5, No. 4, pp. 283-293

[6] Pravin A Renuke Dynamic Analysis of a Car Chassis IJERA Vol. 2, Issue 6, November- December 2012, pp.955-959

[7] B.V. Subrahmanyam, A. Srinivasa Rao, S.V. Gopala Krishna, CH. Rama Krishna Static and Dynamic Analysis of Machine Tool Structures IJRMET Vol. 4, Issue Spl - 1, Nov 2013- April 2014

[8] Namdev a. Patil, laukik p. Raut vibration analysis of ci engine using FFTanalyzer IJERT

[9] Dr. S.C. Jaiswal , Rahul Singh multi body dynamic analysis and simulation of engine model IJRET Vol. 3 No. 10 October 2011

[10] Sondipon adhikariand c. S. Manohar dynamic analysis of framed structures with statistical uncertainties, int. J. Numer. Meth. Engng. 44, 1157{1178 (1999)

[11] Jovan vladic, petar malesev, rastislav sostakov - nikola brkljac dynamic analysis of the load lifting mechanisms journal of mechanical engineering 54(2008)10, 655-661

[12] Piyush k. Bhandari, ayan sengupta dynamic analysis of machine foundation ijret an iso 3297: 2007 certified organization volume 3, special issue 4, April 2014.

[13] Darina Hroncov, Ingrid Delyova, Peter Frankovsky, Anna Puzderova Dynamic Analysis of the Shaping Machine Mechanism American Journal of Mechanical Engineering, 2013, Vol. 1, No. 7, 370-373

[14] T. Raja Santosh Kumar, Suresh Babu Koppula, Cr. Prakash, D.V.Srikanth Design and Dynamic Analysis of Flywheel IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE) e-ISSN: 2278-1684, p-ISSN : 2320–334X PP 51-56.

[15] Giacomo bianchi, stefano cagna, nicola cau, Francesco paolucci analysis of vibration damping in machine tools Science direct procedia cirp 21 (2014) 367 – 372.

[16] Anayet u. Patwari, waleed f. Faris, a. K. M. Nurul amin, and S. K. Loh dynamic modal analysis of vertical machining Centre components hindawi Publishing Corporation Advances in acoustics and vibration Volume 2009, article id 508076, 10 pages.