Research Paper Engineering

Model Analysis of Exhaust Bent Pipe for Checking Condition of Resonance Due to Vibration of Vibratory Compactor (Part-02)

* Quazi Mohd. Jawed Ali **Dr. Suwarna Torgal

* Student ME (Mechanical-D&T) IET-DAVV, Indore- 45201

** Asst. Prof. Mechanical, IET-DAVV, Indor-452017

ABSTRACT

The goal of modal analysis in structural mechanics is to determine the natural mode shapes and frequencies of an object or structure during free vibration. It is common to use the finite element method to perform this analysis because, like other calculations using the FEM, the object being analyzed can have arbitrary shape and the results of the calculations are acceptable. The types of equations which arise from modal analysis are those seen in Eigen systems. The physical interpretation of the eigenvalues and eigenvectors which come from solving the system are that they represent the frequencies and corresponding mode shapes. Sometimes, the only desired modes are the lowest frequencies because they can be the most prominent modes at which the object will vibrate, dominating all the higher frequency modes. The paper presents the predict the condition of resonance due to vibration of machine and natural frequency of exhaust bent pipe using Altair Radioss predictive tool.

Keywords : model analysis, natural frequency, bent pipe

INTRODUCTION

A normal mode of a vibrating system is a pattern of motion in which all parts of the system move sinusoidally with the same frequency and with a fixed phase relation. The motion described by the normal modes is called resonance. The frequencies of the normal modes of a system are known as its natural frequencies or resonant frequencies. A physical object, such as a building, bridge or molecule, has a set of normal modes that depend on its structure, materials and boundary conditions.

Normal Modes Analysis, also called eigenvalue analysis or eigenvalue extraction, is a technique used to calculate the vibration shapes and associated frequencies that a structure will exhibit. It is important to know these frequencies because if cyclic loads are applied at these frequencies, the structure can go into a resonance condition that will lead to catastrophic failure. It is also important to know the shapes in order to make sure that loads are not applied at points that will cause the resonance condition. Typically, the upper bound frequency in this case is 1.5 times the highest loading frequency or response frequency of interest.

Modes are inherent properties of a structure, and are determined by the material properties (mass, damping, and stiffness), and boundary conditions of the structure. Each mode is defined by a natural

(Modal or resonant) frequency, modal damping, and a mode shape (i.e. the so-called “modal parameters”). If either the material properties or the boundary conditions of a structure change, its modes will change. For instance, if mass is added to a structure, it will vibrate differently.

METHODOLOGY USED

FINITE ELEMENT MODELING AND ANALYSIS

Preprocessing: This phase consists of making available the input data such as geometry, material properties, meshing of the model, boundary conditions and has the following steps:

1. Set up: Here we enter the analysis type, the material properties, and the geometry (i.e. prepare the model). The model may be built parametrically or a model from other software package can be imported.
2. Create FE model: In this step we divide the total volume into small simple regular volumes, which can be easily meshed. Then we define the mesh size for each small volume by virtually dividing all the edges of the small volume into same divisions.
3. Loading: In this step the boundary conditions are imposed, i.e. forces and constraints, on the model are defined

Solution: In this phase a solver is used to solve the basic equation for the analysis type and to compute the results. This phase is taken care by the software programme. In the solution process, the solver goes through following steps to compute the solution for a steady state analysis.

1. Formulate element matrices.
2. Assembly and triangularise the overall stiffness matrix.
3. Calculate the solution by back substitution.
4. Compute the natural frequency on defined mode shapes

Post processing: This is the last phase where the results are reviewed for the analysis done, by obtaining graphic displays, vector-plots and tabular reports of stress and displacement, etc. It may take long time to solve or analyze the whole model. Therefore the system used in such complex problem should have high configuration

Measurement of Natural Frequencies: Now we have to find the natural frequencies of exhaust bent pipe using Altair Radioss software. The program is developed to find the natural frequencies

Physical properties of Pipe Material

- Material Specs: COLD DRAWN ERW TUBE AS PER IS: 5429
- Outside diameter of Tube: 63.5 mm
- Tube Thickness: 1.6mm

Chemical Composition

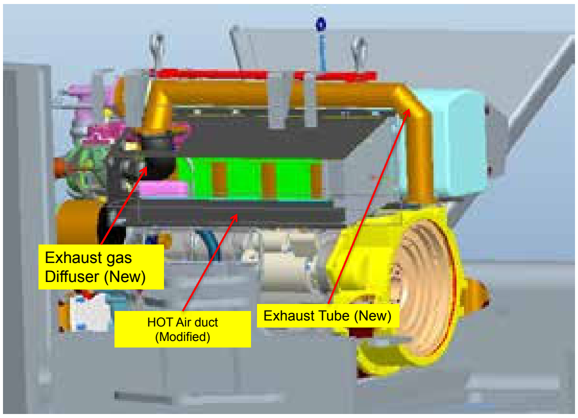
C	Mn	S	P
0.20 (Max)	0.30 - 0.60	0.060 (Max)	0.060 (Max)

Mechanical Properties

- Tensile Strength= 310 (Min) MPa
- Yield Strength= 160 (Min) MPa
- E=2.1e+05 MPa
- Rho=7.9e-09 MPa
- Nu=0.300

Schematic layout of exhaust bent pipe: In part-01 paper on failure analysis we studied arrangement of pipe fitment on machine same is shown below for quick referral

Fig-01: Schematic layout of exhaust bent pipe



PREPARING FEA MODEL:

The IGES model of pipe is imported in Hyper mesh for discretization as per below details

- Element Type= Tetra4 (3D Elements)
- No of element formed=166722
- No. of Nodes formed= 54522

Fig-02: FEA model of pipe

BOUNDARY CONDITION :

In frequency response function both ends of pipe is constrains by all 6 degree of freedom, in practical arrangement pipe is mounted on both end by using bolts to arrest its movement

Now using Altair Radioss software, normal mode analysis for all 6 degree of freedom (3 translatory and 3 rotatory) is given as an input in preprocessing of the FEA model

POST PROCESSING OF RESULTS:

Natural frequency of different mode shape is observed as follows

Mode	Natural Frequency
1	3.09E+02
2	5.05E+02
3	6.94E+02
4	7.49E+02
5	1.26E+03
6	1.53E+03

Different Mode shape obtain :

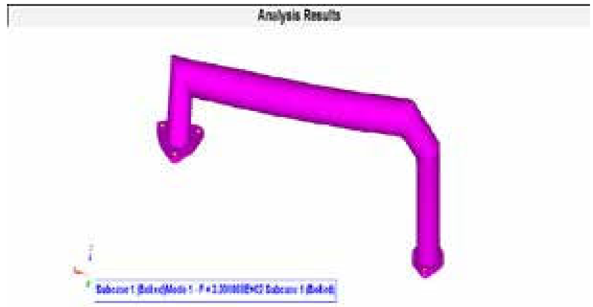


Fig-03: Mode Shape-01

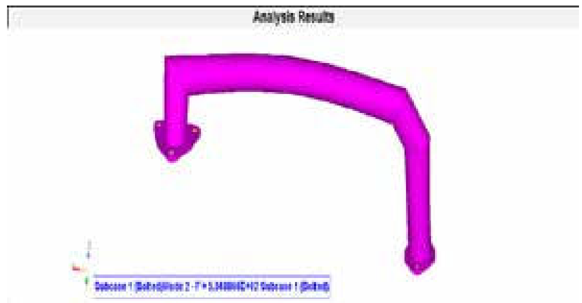


Fig-04: Mode Shape-02

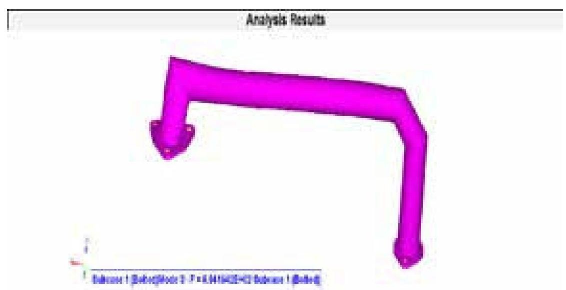


Fig-05: Mode Shape-03

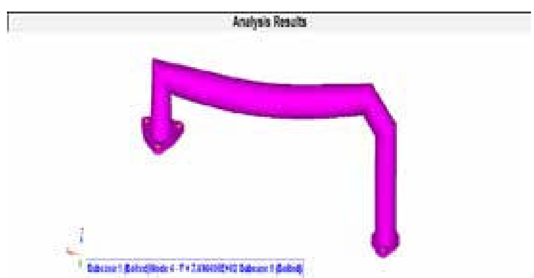


Fig-06: Mode Shape-04

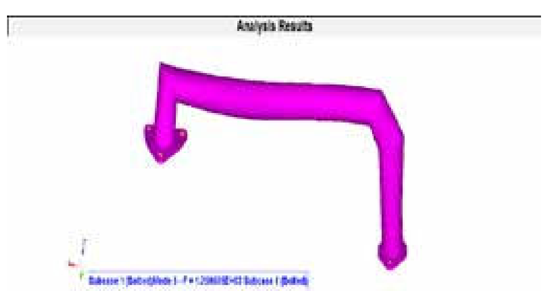


Fig-07: Mode Shape-05

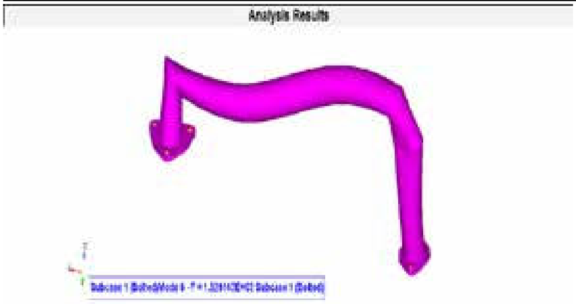


Fig-08: Mode Shape-06

COMPARISION OF NATURAL FREQUENCIES WITH VIBRATION OF MACHINE

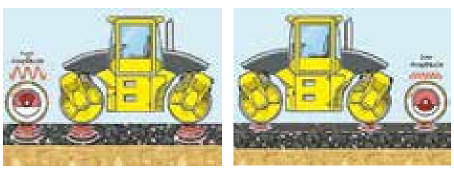
Vibration details of Vibratory Compactor

1. Nominal amplitude (Stage 1)= 1 mm
2. Frequency (stage 1)= 33.3 Hz

High amplitude, Low frequency; used for heavy soil compaction

3. Nominal amplitude (Stage 2)= 0.4 mm
4. Frequency (stage 2)= 50 Hz

Low amplitude , high frequency; used for small soil compaction



Vibrations of Machines are as follows

1. Frequency (stage 1)= 33.3 Hz
2. Frequency (stage 2)= 50 Hz

RESULTS AND DISCUSSION

On comparison of natural frequency of pipe with both stage vibration of machine it is observed that pipe is much in safer design and there is no condition of resonance

Mode	*Natural Frequency of pipe*	*Vibration frequency of Machine*
1	*3.09E+02*	*Frequency (stage 1)= 33.3 Hz* *Frequency (stage 2)= 50 Hz*
2	*5.05E+02*	
3	*6.94E+02*	
4	*7.49E+02*	
5	*1.26E+03*	
6	*1.53E+03*	

CONCLUSIONS

The exhaust bent pipe 3D-model was created in Pro-ENGINEER software and then it was imported to Altair Hypermesh software for analysis. The differences in natural frequencies obtained from normal mode analysis are very less compared to vibrating frequency of machine. So we can conclude that there will not be any condition of resonance and hence implementation of modified layout is safe in all field machines running on different applications

REFERENCES

[1] Olson, D. E., "Piping Vibration Experience In Power Plants," Pressure Vessel and Piping Technology, A Decade of Progress, Book No. HD0330, ASME (1985). | [2] Wachel J.C. and Bates, C. L., "Techniques ForC0ntrolling Piping Vibrations and Failure," ASME paper 76-PETIB (1976). | [3] Wachel, J.C. , "Piping Vibration and Stress," Proceedings of the Machinery Vibration Monitoring and Analysis , Vibra- tion Institute (April 1981). | [4] Wacbel,J.C., Atkins, K. E., ct al., "Vibrations in Reciprocating Machinery and Piping," Engineering Dynamics Incorporated Report 35-305 (1985) | [5] Blevins, R. D., "Formulas for Natural Frequency and Mode Shape," Van Nostrand Reinhold Company, (1979) | [6] Harris, C. M., and Crede, C. E.., Shoal: and Vibration Handbook, 1, Basic Theory and Measurements, New York, New York: McGraw-Hill (1961)