Design of Semi-Automatic Vibration Absorber by using FEA

R. S. Autade[1], S. A. Pawar[2], A. B. Atpadkar[3]

[1] *Asst. Professor, Dept. of Mechanical Engineering, Fabtech college of engg., Maharashtra, India.*
[2] *Asst. Professor, Dept. of Mechanical Engineering, Fabtech college of engg., Maharashtra, India.*
[3] *Asst. Professor, Dept. of Mechanical Engineering, Fabtech college of engg., Maharashtra, India.*

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Abstract – *When any elastic body such as spring, shaft or beam, is displaced from the equilibrium position by the application of external forces & then released, it commences cyclic motion. Such cyclic motion of body or a system, due to elastic deformation under the action of external forces, is known as vibration.*

The dual mass vibration absorber can be effectively used to reduce the vibration of the beam. This absorber is tuned to excitation frequency by moving the dual masses in or out easily. The experimental result shows that around the absorber attachment location the vibration of beam become negligible. This absorber also reduces the vibration of beam other than attachment point.

Key Words: *Active DVA, passive DVA, mode shapes etc.*

1. INTRODUCTION When any elastic body such as spring, shaft or beam, is displaced from the equilibrium position by the application of external forces & then released, it commences cyclic motion. Such cyclic motion of body or a system, due to elastic deformation under the action of external forces, is known as vibration.

When machines are operating they create vibrations. In some cases these vibrations have a negative influence on the performance of the machine. For instance, in a milling machine the whole construction vibrates when the tool rotates and material is cut. This can have a negative impact on the precision of the manufactured products, the lifetime of the machine and the environment. A solution to this problem can be found in the application of dynamic vibration absorber (DVA). A DVA is a construction that can be mounted on the vibrating machine and which is connected to a controller. Whenever the vibration characteristics of the machine change, the controller adjusts the DVA so that the vibrations get damped as good as possible. The aim is to design active DVA.

1.1 PRINCIPLE OF ABSORBER:

As shown in Fig 1.1 a sinusoidal force $F_o$sinwt acts on an undamped main mass-spring system (without the absorber mass attached).When the forcing equal the natural frequency of the main mass the response is infinite

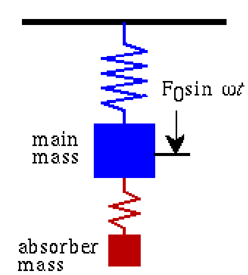

Fig 1.1 Principal of vibration absorber

This is called resonance, and it can cause server problems for vibrating system. When an absorbing mass-spring system is attached to main mass and the resonance of the absorber is tuned to match that of the main mass, the motion of the main mass is reduced to zero at its resonance frequency. Thus, the energy of the main mass is apparently "absorbed" by the tuned dynamic absorber.

1.2 APPLICATION

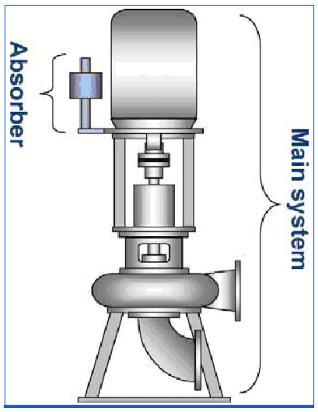

Fig 1.2 Application of vibration absorber to reduce the vibrations of variable speed pump

The application of a TVA for suppression of chatter vibrations in the boring manufacturing process is presented. The boring bar is modeled as a cantilever Euler–Bernoulli beam and the TVA is composed of mass and spring and dashpot elements.

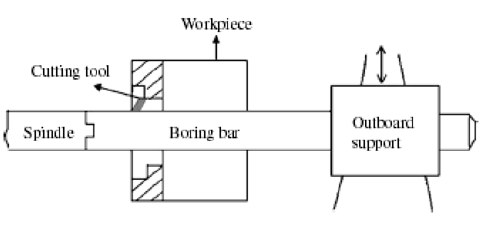

Fig 1.3 Application of vibration absorber to reduce the vibrations of boring bar

2.1 MODAL ANALYSIS OF ABSORBER

In order to gain an accurate prediction of the modes of the absorber, a numerical analysis using finite elements was used. This analysis allows determination of the resonance frequency of each mode, which will be a function of the location of the mass along the two shafts. The suitability of this element was based on its bending and membrane properties. For the modeling of the two shafts, absorber masses & housing SOLID92, tetrahedral was used. More detail can be found within the ANSYS manuals.

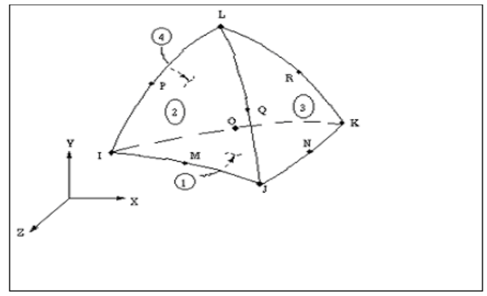

Fig 2.1 Solid92 3-D-Node tetrahedral structural solid.

SOLID92 is well suited to model of irregular meshes. The element is defined by 10 nodes having three degree of freedom at each node translations in the nodal in x, y, and z direction.

The boundary conditions were then programmed by fixing (in all directions) one side of the square housing. Note that one of the shafts will be threaded and the other is smooth. When absorber is turned, the end masses will move in or out.

Dimension and properties of the absorber

Length of rod = 160mm,

Diameter of rod = 6mm,

Length of mass = 25mm,

Diameter of mass = 40mm,

Density of material = 7800 kg/m^{3},

Modulus of elasticity =200Gpa

2.1.1 Analysis of absorber

Fig 2.2 shows the mode shape of absorber for the first six natural frequencies. For the first two mode shapes masses moves laterally in horizontal direction. For the first mode shape the mass moves out of phase and for second mode shape move in phase

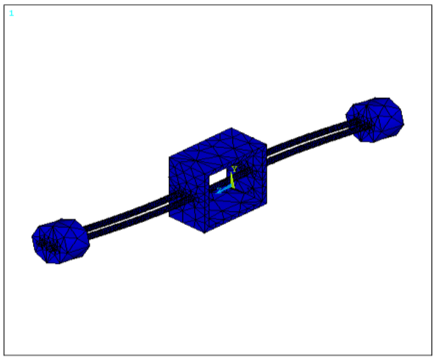

Fig 2.2a) First mode shape at frequency 49.8 Hz

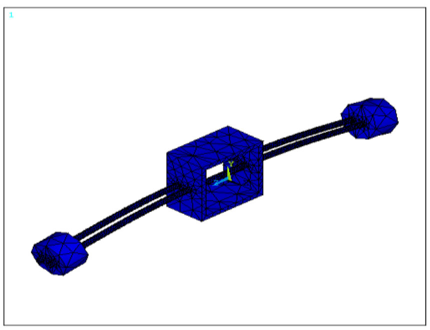

Fig 2.2 b) Second mode shape at frequency 49.9Hz

For the third and fourth mode shapes masses moves in vertical direction. For the third mode shape the mass moves out of phase and for fourth mode shape move in phase

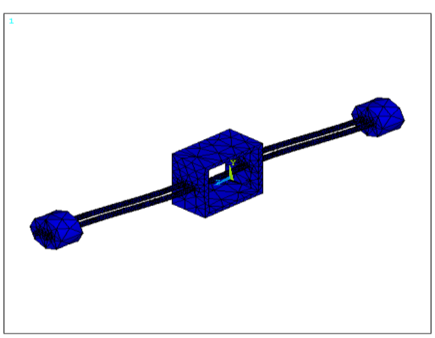

Fig 2.2 c) Third mode shape at frequency 97.3 Hz

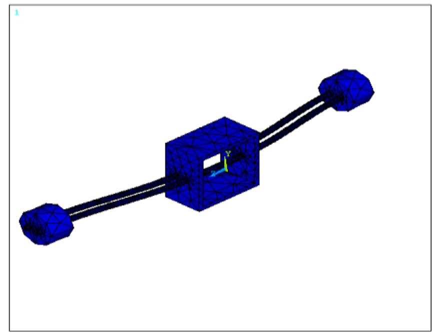

Fig 2.2d) Fourth mode shape at frequency 99.27Hz

For the fifth, sixth mode shapes the masses are in torsion. For the fifth mode shape the mass moves out of phase and for sixth mode shape move in phase

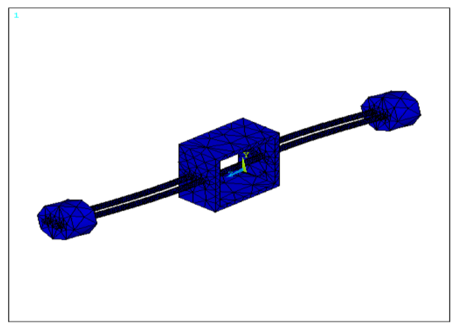

Fig 2.2 e) Fifth mode shape at frequency 279.1Hz

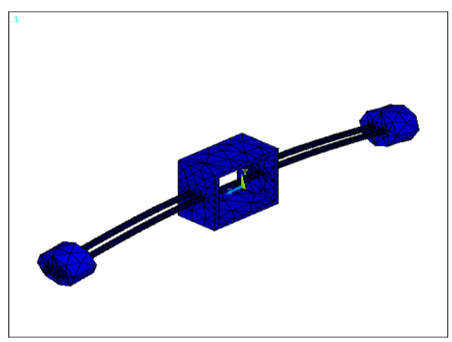

Fig 2.2 f) Sixth mode shape at frequency 279.1 Hz

Fig 2.2: Mode shapes of dual mass absorber for first six natural frequencies.

Table 1: Frequencies for different mass position along rod length

Mass pos. in mm	Frequency (Hz)					
	1	2	3	4	5	6
130	49.88	49.94	97.36	99.27	27.17	279.18
125	51.79	51.86	101.48	103.5	283.69	283.71
120	54.35	54.42	107.05	109.3	289.70	289.72
115	57.13	57.21	113.15	115.69	296.17	296.19
110	60.10	60.19	119.85	122.68	303.08	303.11
105	63.31	63.41	127.23	130.42	310.53	310.61

From table it is seen that for different mass positions from outside to inside frequency goes on increasing and vice versa. In this table shows first
six frequencies for various position

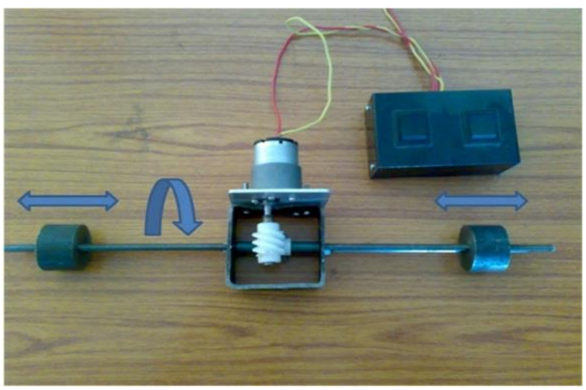

Fig. 3 Dual Mass Vibration Absorber

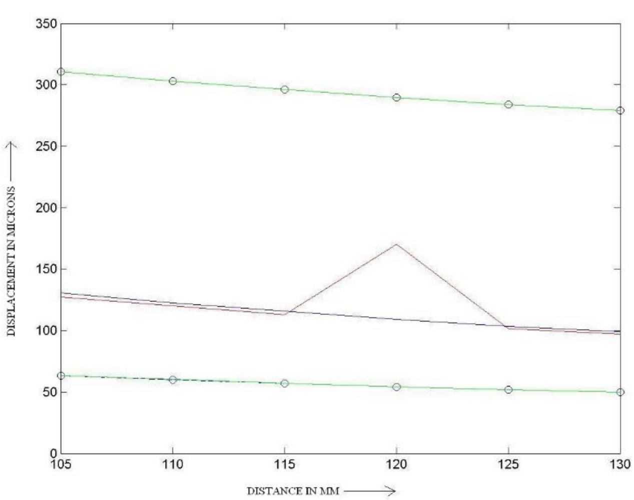

Fig. 2.3 Graph of variation of frequency (Displacement in microns) with distance (position) of masses.

CONCLUSIONS: The dual mass vibration absorber can be effectively used to reduce the vibration of the beam. This absorber is tuned to excitation frequency by moving the dual masses in or out easily.

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