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Performance of Particle Impact Damper on a Beam for Vibration Suppression

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Abstract - ***The vibration creates problem to serviceability requirement of the structure and also reduce structural integrity with possibilities of failure. A study made up of general behaviour of particle impact damping. The exact study is done with help of experimentation. In the particle dampers the enclosures partially filled with metallic fine spheres, attached to the vibrating structure. The traditional damping materials frictional and energy dissipation and impact phenomena which are highly nonlinear. (PID) particle impact damping is a means for achieving high damping performance by the means of particles of various materials filled inside the enclosure. The various particles are strikes on wall of the enclosure as well as on each other and absorbs the kinetic energy of the structure and convert it into heat. In this work the study is conducted on the cantilever beam. The enclosure is attached at the free end of the beam. The enclosure is filled with the copper particles. These particles are used for the vibration suppression. In this study the aluminium material is used for the cantilever beam so on that beam carry out the experimental work. The beam with and without particles are studied for satisfactory damping performance. The experimentation is carried out on the beam for the effective particle size and to select the best damping ratio of the particles.***

Key Words: *Damping, Impact, Friction, Vibration, etc.*

1. INTRODUCTION

The displacements of the particle, body or any system of connected number of parts moves from the position of equilibrium is known as vibration. The machines and the structures mostly contains unwanted vibrations which effects and produces increased stresses, energy losses, causes wear, increases in the excess bearing load, increases in the fatigue, excess vibrations in the vehicle causes uncomfortable to passengers, which decreases the efficiency of the system also in the rotating machines when it rotates it generates vibrations above the balance ratio etc.

Vibrations arises if the system dislocate from its equilibrium position. The system retrieves to return its initial equilibrium position under the restoring forces (such as elastic forces, gravitational forces, for a simple mass is attached to a spring, for a pendulum). The system tends to keep back to its original position of equilibrium. The system is the combination of the elements. They act together to accomplish the objective. For example an automobile is the system which is the combination of the elements (wheels, car body, suspension, and so forth) work together. The output of the static element whose is the given time only depends only on the input at the while the dynamic element is one whose output depends on the past dynamic. In this way we speak the static and dynamic systems [11]. In static system which contains all the elements. In the dynamic system which contains at least one dynamic elements.

The analytical study of the particle damper established the particle dynamics method developed for the kinematics of particle damping, containing the shear friction between the particles of the materials and contacting area with particles and the dissipation of energy in terms of heat of the particle material. Contact forces between the particles and the enclosure walls are intended based on force displacement relations [8]. Particle impact damping gives the high damping performance, granular particles are place into their respective holes into vibration structure. The elastic cantilever beam is drilled through horizontally and these holes are filled with the particles. Reduce the vibrations by shear friction produced by shear gradient with the lengthwise to the structure. A physical model to determine the shear forces between the particle layers and the impact of the particles on the inside of the hole. A numerical procedure to determine the damping effect of vibrating structure. Experimental test on the beam and plate to calculate the various damping treatments. The particle impact damping is found effectively robust for a broadband range [1].

2. METHODOLOGY

Beam or a cantilever beam is a horizontal or vertical structural part that is accomplished of withstanding the load primarily by resisting bending. The bending force persuaded into the material of the beam it result into the external loads, own weight, span and external reactions to these loads is called a bending movement. Beams are conventionally accounts of building or civil engineering

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structural rudiments, but smaller structures known as truck or automobile frames, machine frames, and other mechanical or structural systems encompass the beam structures that are designed and analysed in a similar fashion. As in this experiment use the aluminium material cantilever beam.

2.1 The beam with particle damping treatment

A cantilever beam of aluminium material is selected. The specifications of the beam are as shown in table 1.

Table 1:- Beam Specifications

ALUMINIUM BEAM	
Flexural Member	Beam
Material	ALUMINIUM
Length	450 mm
Width	50 mm
Depth	3 mm
Boundary Condition	Cantilever
Mass Density	2700 kg/m3
Modulus of Elasticity	69-70 GPa

As in this experiment, maximum numbers of enclosure are 1. Aluminium rod is used and the size of 46 mm in diameter with the help of lathe, enclosure are made up of size of OD- 40mm, ID -38 mm, for the base of enclosure drill of 5mm was done for proper fixing. The weight of the enclosure is 48.14 g. the height of the enclosure is 40 mm. To seal the enclosure at top, a cover is developed of aluminium material only. The effective location selected for the enclosure is the free end of beam. The copper particles are used in this study of the size of 6mm, 8mm, and 10mm with packing ratio changes for every size is 0% to 75% into steps of 25%.

2.2 ANALYSIS OF BEAM

2.2.1 Modal Analysis

The modal analysis is carried out for undamped cantilever beam to find out its natural frequency for various mode shapes. Before damping the natural frequency of cantilever beam is 14.85 Hz. Also we calculate it for different mode shapes of cantilever beam to find its percentage change in natural frequency to every mode after damping. The ANSYS results of natural frequency of undamped beam for different modes are presented in following figures.

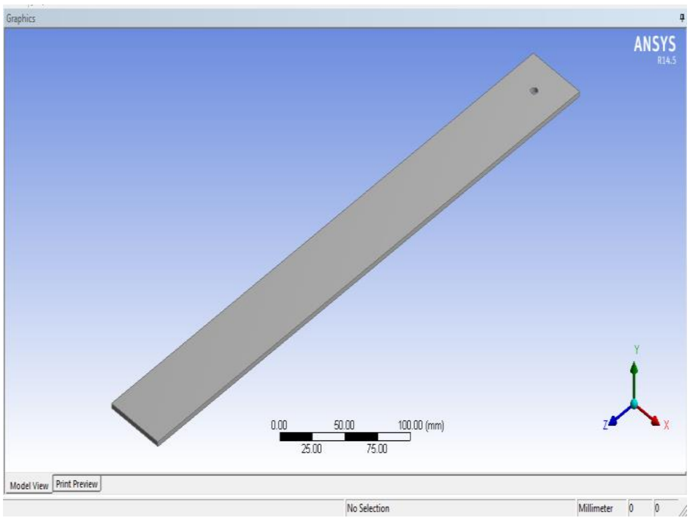

Fig 1:- Geometry of Aluminium beam in ANSYS

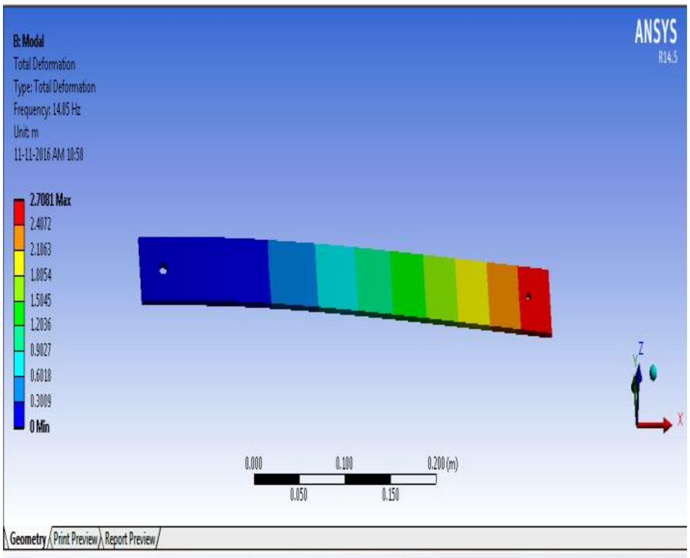

Fig 2:- Modal analysis of cantilever beam

Table 2:- Mode and Natural Frequency of the cantilever beam

Mode	Frequency [Hz]
1.	14.85
2.	92.967
3.	163.21
4.	239.95
5.	260.23
6.	509.94

Fig 3:- Beam configured with particle impact damping

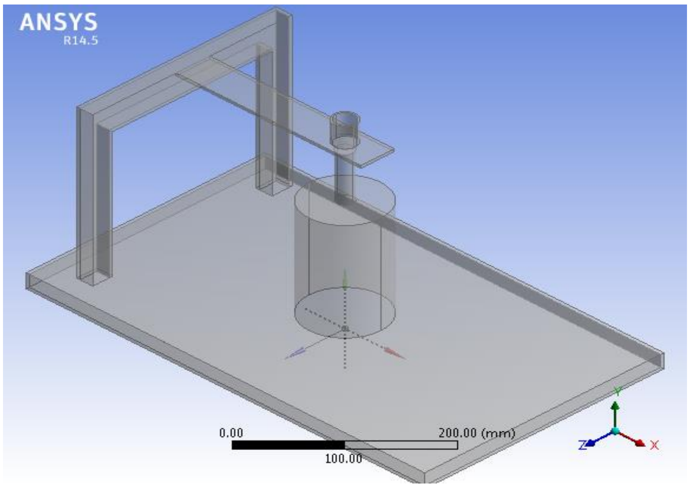

Fig 4:- Geometry of Experimental set up

The fig 3 shows the cantilever beam consist of particle impact damper is connected to its free end.

The experimentation are conducted for the transient and forced vibrations. The three sizes of copper material selected those are 6mm, 8mm, and 10mm and the packing ratio selected in the steps of 25% and range from 0% to 100%. The enclosure is fixed at the end of the cantilever beam for the transient vibration initial displacement is given to the free end of the beam. The beam is allowed to move freely and the reading are taken. The readings are also conducted for the forced vibration as same as discussed above. The exciter tip is kept on exact below of the beam free end. The enclosure is fixed at the free end of the beam and the accelerometer is attached near to the enclosure point of excitation. The frequency range of interest is 8 to 24 Hz

3. RESULTS AND DISCUSSIONS

3.1 Transient Excitation

The fig. 5 and 6 shows the performance of the sizes which are selected for the experiment. In this experiment fig 5 and 6 shows the effect of the acceleration vs. packing ratio and displacement vs. packing ratio. The graph of acceleration and displacement are nearly same in the nature for all type of materials and all sizes of particles. The nature of acceleration and displacement various with the packing ratio. The packing ratio is changes from 0% to 75% with step of 25%. The particles studied for this study are 6 mm, 8 mm, 10 mm. The nature of acceleration and displacement is changes from 0% to 25% and 25% to 50% and 50% to 75%. The acceleration and displacement is more for 0% packing ratio and it reduces to the packing ratio 25%. After 25% packing ratio it increases up to 75%. This effect is occurs due to proportion of impact phenomena and friction phenomena on the beam while damping. So the results are show that the 25% to 50% packing ratio is greatly effective for particle impact damping.

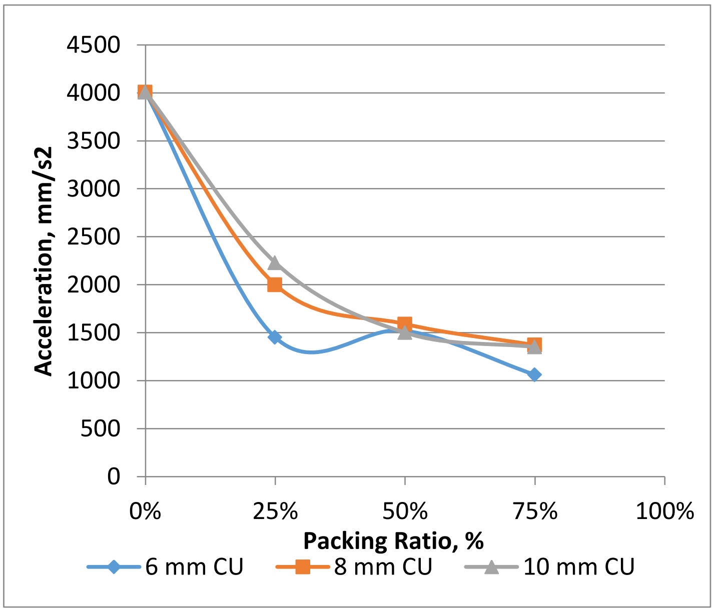

Fig 5:- Acceleration versus packing ratio for transient vibration

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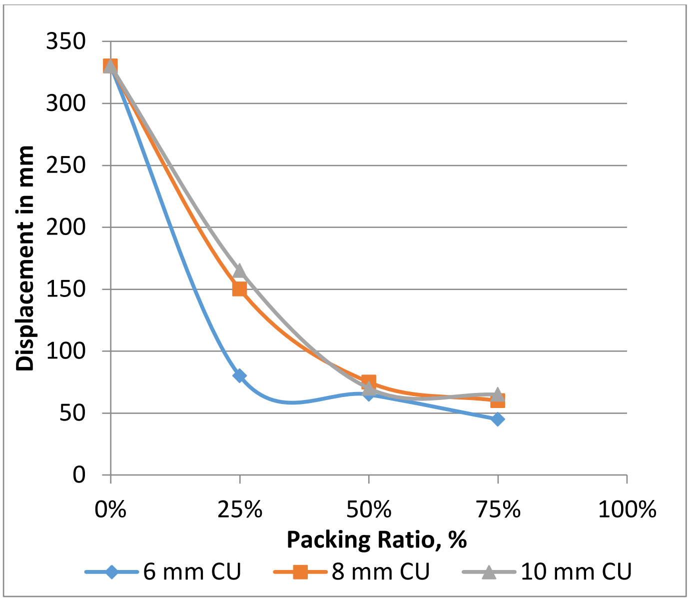
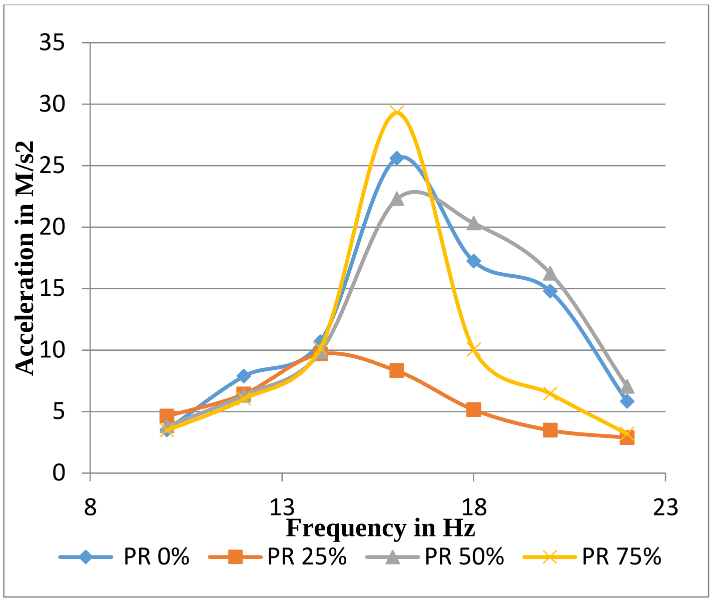


Fig 6:- Displacement versus packing ratio for transient vibration

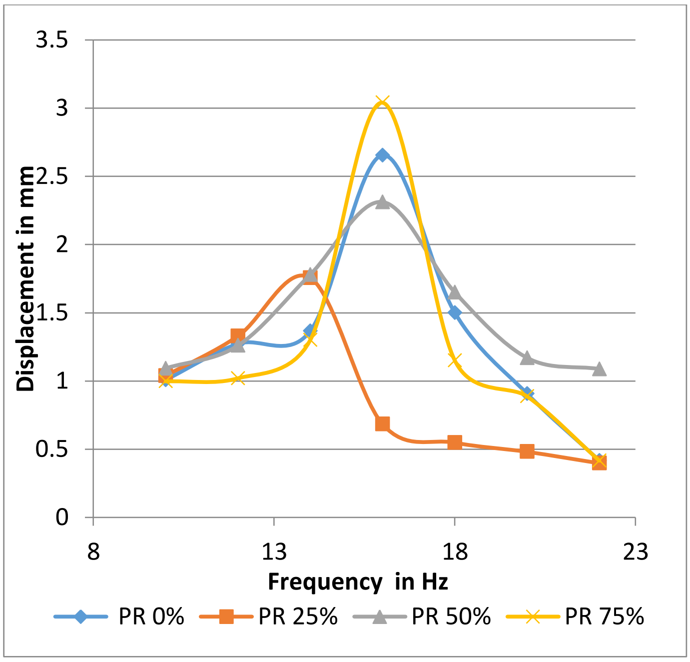
The displacement and acceleration is directly proportional to the movement of the particles inside the enclosure. Additionally when the size of particle is decreases the number of particles are increases and mass ratio increases, so that the impact of particles and wall of enclosure increases. So the size 10mm particles gives the minimum damping performance because of the increase in damping performance and decrease in friction effect. When the no of particles are increased the friction effect increases but at the same time the impact effect decreases. So the highly damping effect is achieved by using 6 mm particles and 50% packing ratio.

3.2 Forced Excitation

Fig 7 to fig 9 shows the performance of the sizes which are selected for the experiment. In this experiment fig 7 to 9 shows the effect of the acceleration vs. frequency and displacement vs. frequency for the size of 6mm, 8mm, and 10mm for four packing ratios of each particle size. When the 0% packing ratio means there are zero particles present into the particle impact damping enclosure. This shows that zero particles means no damping effect be because of there are absent of impact and the absent of friction so there is no any heat loss. Nevertheless the packing ratios from the range of 25% to 75% found the different in the damping effect seen easily as well as in the impact and the friction effect. For the impact effect there is need of the excitation for this the acceleration of the beam is more than the acceleration due to gravity for that case choose the excitation frequency range is selected 8 Hz to 24 Hz for the experimentation.



(a) Acceleration

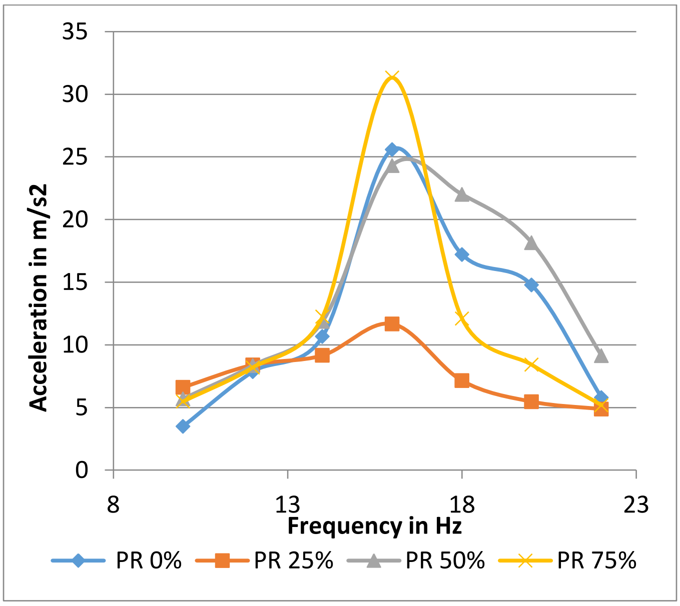


(a) Displacement

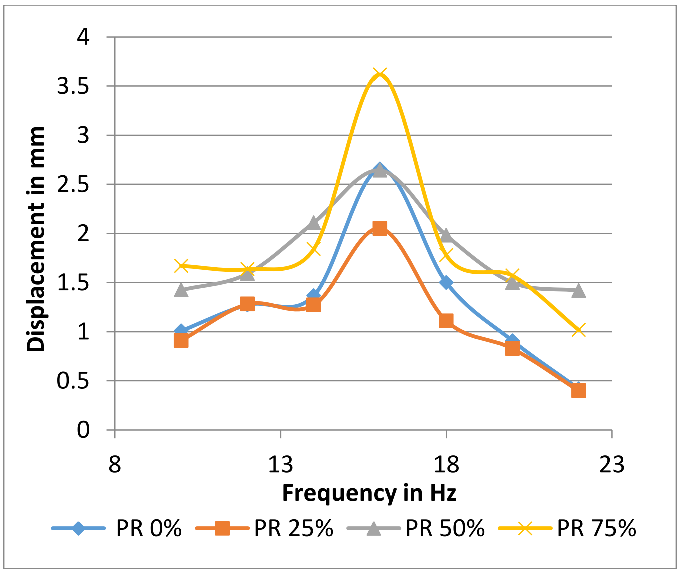
Fig 7:- Comparison of acceleration and displacement versus excitation frequency for forced vibration of 6 mm Cu balls.

Fig. 7 gives the damping performance of the cantilever beam with the particle size of 6 mm. It is found that the highest damping effect is for the packing ratio of the 25% from the comparing of the other packing ratios. This is happen because the impact of the particles increases and the friction effect decreases. It is found that the effective packing ratio is from range 25% to 75% and the best damping ratio is 25%.

Fig 8 shows that the damping performance of the particle size 8 mm. and it is found that the highest damping performance is found at 25% packing ratio amongst the other packing ratios. There is the 50% and 75% packing ratio is closely related to each other. For the damping effect of 25% packing ratio there is the friction effect is less and the impact effect is more for the particles. When the damping effect for the packing ratio 50% and 75% there is the is the friction effect dominate the impact effect. So all of them the effective damping of packing ratio is 25%.



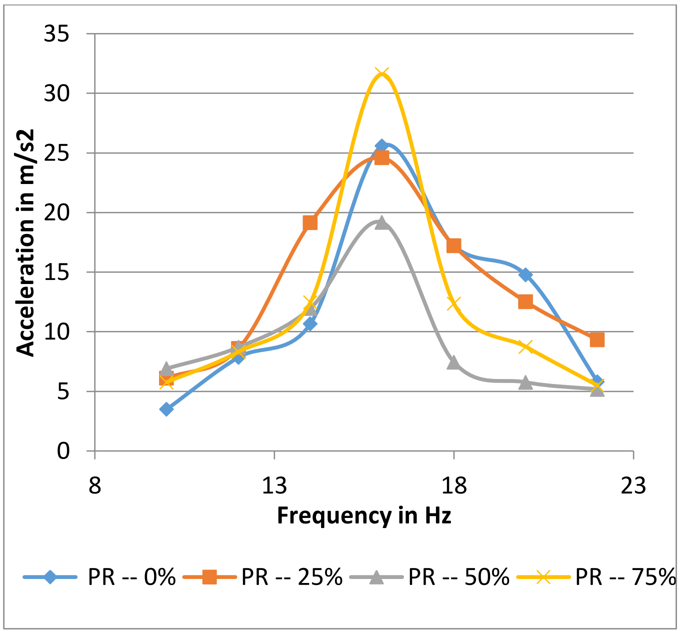
(a) Acceleration



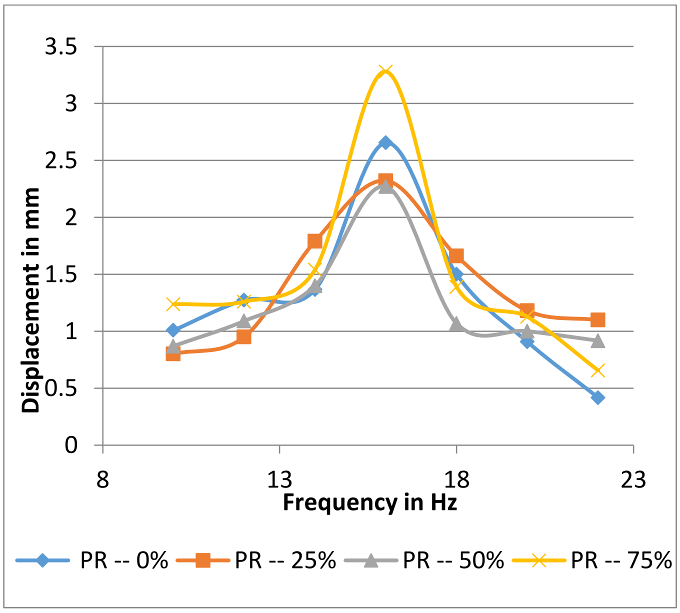
(b) Displacement

Fig 8:- Comparison of acceleration and displacement versus excitation frequency for forced vibration of 8 mm Cu balls.

For fig 9 revels that the particle impact damping performance of 10 mm size balls. The best particle impact damping performance is for the 50% packing ratio comparing the other damping packing ratios. For the packing ratio of 50% there is the size of the particles increased. For the bigger size of particles there is the impact effect decreases and the friction effect is increases. So the packing ratio of 50% gives the maximum damping effect.



(a) Acceleration



(b) Displacement

Fig 9:- Comparison of acceleration and displacement versus excitation frequency for forced vibration of 10 mm Cu balls.

4. CONCLUSION

It is observed that, one of important factors, considered for the particle impact damping is size of the particles. The 6 mm dia. particles of copper material is found effective as comparison to other sizes (8 mm, 10 mm) of copper material, for the transient as well as forced excitation. Also it is found that, packing ratio also effects on the vibration suppression. The effective packing ratio is found to be in between 25% and 50% for the forced excitation.

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