DESIGN OF PASSIVE COMPOSITE ISOLATION SYSTEM FOR MACHINE FOUNDAION

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Abstract— **The contribution of design has been essential to the more recent developments in new machine foundation isolation. The vibration is desirable or undesirable; it depends on working situation, but necessarily produces minimum in operating condition. To minimize vibration level, isolators are equipped for getting minimum transmissibility. In this work, the specimens of composite material have been designed, manufactured for the medium weighted machine foundation to isolate the vibration. Also the isolator is designed and manufactured by changing the different layers combination and it analyzed by ANSYS. For the sake of comparison, isolation member has been tested by vibration shaker, and machine foundation vibrations are checking by FFT Analyzer. As the composites are gives the minimum natural frequency, the isolation effect is increases for the machine foundation.**

Keywords-(vibration);(isolaters);(composite);(passive);

(dynamic loading)

I. INTRODUCTION

The purpose of vibration isolation is to prevent unwanted vibration. So that, it's adverse effects are kept within acceptable limits. Vibrations produced from machines or other sources are transmitted to a support structure such as a facility floor, causing a chatter vibration in machine or noise in working area.

Waves produced by the machine can adversely affect the other machines also which are nearby to the structure. There are various methods for isolating this vibration like,

1) Active type isolator
2) Passive type isolator.

In these type there has been various equipment are used according to the machine specification e.g. spring mounting pneumatic system, combine spring and damper system, damping material etc. In the present work the composite type of vibration isolator is used for machine base as isolation pad. There has been different type of passive isolator are used as a machine foundation damper, by laminating different type of epoxy material one over another, the material doesn't have enough strength of machine static loading. To improve the damping effect and static loading capacity new combination has been developed by the materials like mild steel, cork and rubber, with different dimensions. New dampers are made by the above material with different layer combination and those combinations of isolators are analyzed by the ANSYS and checking with the actual experimental setup with the help of FFT Analyzer. For the checking of crack in material it is tested with the help of spectral dynamics by exciting with different frequency.

Vibration, like sound, waves travels in all directions away from a source to surfaces where it can be radiated as noise. For example, the motor in a device that produces the most noise, but it also depends on the panel or structure to which the motor is attached. Use of vibration isolators can stop the flow of vibration from one point to another and reduce noise.

While isolators are available in a very broad variety of designs, all have one characteristic in common: they provide a means of connecting two structures so as to provide relative motion between them under dynamic loads. The amount of motion required depends on many variables, the chief one being the range of frequencies over which the isolator must be effective and stress level for the vertical force.

II. LITRATURE SURVEY

Jyant Kumar has done work on, Dynamic response of footing and machine with spring mounting base. In these work, the effect of spring mounting cushion type of isolator is inserted between the concrete block and machine base. It has been tested by experimentally for block vibration. For the experimentation the machine is in the vertically loaded and it has been checked by harmonic motion. By these research, for different footing block the frequency is different and for some of the case it excide the resonance level. By analyzing the different testing, proper block size is defined for experimental setup [1].

Ghasem Dehghani Ashkezari et.al.(2008) present work on Design, manufacturing and evaluation of the performance of steel like fiber reinforced elastomeric seismic isolators, in which combination of rubber and steel wire materials has been used and that combination of layer are tested on vertical as well as horizontal loading condition for static loading condition by which change of deformation has

been studied the equivalent viscous damping ratio has been determined for the composite structure [6].

Pedro Jorge and Hugo Policarpo has been studied Cork composition damping layer to reduce vibrations, in 2012. He was attempt for the work of combination of steel plate and cork material. The result was concluded by finite analysis and comparing with experimental checking by FFT Analyzer. It is shown the validity of the dynamic properties of the cork composition material determined using a hybrid analytical. Experimental methodology based on a simple three-layered specimen, developed by some of the authors in previous works. Finite element (FE) models have been developed to compare with results obtained from the experimental tests of the damping treatments that have been carried out. The obtained results show a good agreement between the numerical and experimental frequency response functions (FRFs) [8].

Mustapha Assarar et.al. has done work in Analysis of the Damping of Sandwich Materials and Effect of the Characteristics of the Constituents, In the work modeling of the damping properties of sandwich materials that was implemented considering the theory of sandwich plates and using a finite element analysis. The analysis derives the strain energies stored in the material directions of the foam core and in the material directions of the layers of the skins. Further, the energy dissipated by damping in the structure can be obtained as a function of the strain energies and the damping coefficients associated to the different energies stored in the material directions of the core and the layers of the skins [3].

Finite element analysis and experimental verification of the scrap tire rubber pad isolator by Huma Kanta Mishra et.al. in 2013. A new base isolation system using scrap tire rubber pads (STRP) has been introduced for seismic mitigation of ordinary residential buildings. The rubber and the steel reinforcing cords used in manufacturing the tire are the alternative materials of the proposed base isolation system. The steel reinforcing cords represent the steel plates used in conventional laminated rubber bearings. These steel reinforcing cords shall prevent the lateral bulging of the rubber bearing. On the experimental setup the object was tested in vertical and horizontal force test. And the damping factor is calculated by the formula with respect to experimental test results. This paper describes the investigation of a seismic isolation device using scrap tire rubber pads (STRP). Performance of STRP isolator with interleaved steel reinforcing cords is evaluated by means of experimental test and FE analysis [7].

Mr. Ashirbad Swain introduced, Analysis of machine tool structure using RSM Approach. In the research work unwanted vibration in machine tools like milling, lathe, grinding machine has been reduced because one of the main problem as it affects the quality of the machined parts, tool life and noise during machining operation. The part to be machined is kept on sandwich of plates made up of polymer and composite material. The sandwich along with the part to be machined. Composite structure material fixed on the slotted table of horizontal milling machine. In the work, 3 types of secondary bed materials are stacked together below the work piece to form the sandwich and the main effect plot shows the variation of response parameter with respect to controllable parameter. It can be concluded that for of the decided level setting PP and PVC are the useful secondary bed material than GFE [4].

Experimental Analysis of Passive Damping Technique on Conventional Radial Drilling Machine Tool Bed using Composite Materials has attempted by Krishna Mohana Rao in 2013. Machine tool structures Drilling machines are subjected to regular unwanted vibrations or chatter. It results in degraded quality on the machined parts, shorter tool life, and unpleasant noise, hence are to be necessarily damped out. In the work, the chatter vibrations on a slotted table Radial Drilling machine have been damped out using composite structure as a substitute for the base of the work piece. The signal and RMS amplitude, frequency and time period of vibrations are recorded for different number of layers. Moreover, experiments are also conducted without any composite material below the mild steel specimen. As the epoxy type material is used as a secondary bed for drilling mild steel plate, it has good damping characteristic. In the experimentation observer that the level of vibration is get reduced with the increasing the layer of material up to seatrain level. As the increases the layer by optimum stage the chatter vibration has been observed. With improper nut and bolt joint there is a danger of additional slip vibrations between the plates [10].

E.V. Golysheva Vibration protection for an operator of a hand-held percussion machine. A study showed that passive vibration attenuation systems that combined vibration isolation and dynamic absorption principles can significantly reduce vibration perceived by the operator of hand-held percussion machine. Such a system consists of the vibration isolators placed between the vibrating casing and the handle and the dynamic absorber attached to the handle for suppression of the dominant harmonic of handle acceleration that is not affected by vibration isolation [11].

Gyung Ju Kang1 Dynamic analysis of fiber-reinforced elastomeric isolation structures This paper presents an analysis of seismically isolated buildings using fiber-reinforced elastomeric structures that are subject to excitations caused by earthquakes. In analyzing the vibrations, the buildings are modeled by lumped mass systems. The analytical seismic response of multi-storey buildings isolated by fiber-reinforced elastomeric isolators is investigated under strong earthquake conditions [12].

III. Objective of work

The main purpose of this work is to isolate the vibration of machine foundation, by providing the composite material isolator in machine foundation. As some machines does not having a rigid foundation and all the vibrations are transmit to surrounding structure. To prevent this phenomenon, composite types of isolator are designed and manufacture.

IV. METHODOLOGY

The design and manufacturing of composite isolator is as follows:

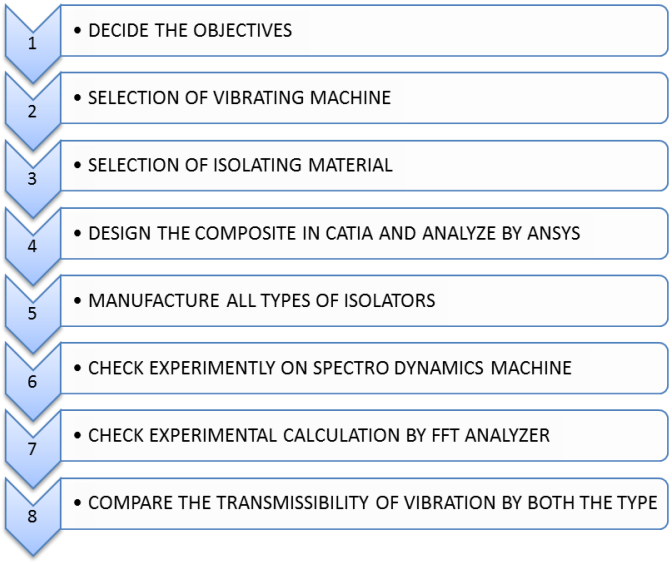

Fig.1 work flow chart

V. ISOLATION DETAILS

The foundations are subjected to static or dynamic load or combination of both. The static loads are imposed on the foundations slowly and gradually in such a way as to avoid any vibration of the foundation system. The dynamic loads are time variable load, e.g. Earthquake, impact, blast loads etc. Displacement and stresses are time dependent. The inertia forces are part of the loading system.

As the dynamic load having several phenomenon, to prevent them different types of isolating materials are selected for isolation pad. All the machine which have rotating or reciprocating motion they have weight and acts in downward direction, for these types of static loading member should have the good strength to carry the load. As per these properties, different materials are selected for the application.

A. *Material selection*

For the isolation purpose for foundation, mild steel, cork and natural rubber are selected. The materials are selected by their property of damping as well as strength factor. For selection of mild steel its strength and loss factor for damping purpose is taking in consideration. As it is in the range of 0.0001 and damping ratio 0.004, the mild steel is selected for top layer of isolator. For second material i.e. cork, having 0.0125 damping ratio and natural rubber having damping ratio of 0.05 [2]. The damping ratio of cork and rubber is high and transmissibility value is low [5]. By this theory of specification, materials are selected for isolation purpose with the help of transmissibility graph. As shown in the fig 1, as the transmissibility is low the frequency ratio is also decrease by selecting the high damping factor material.

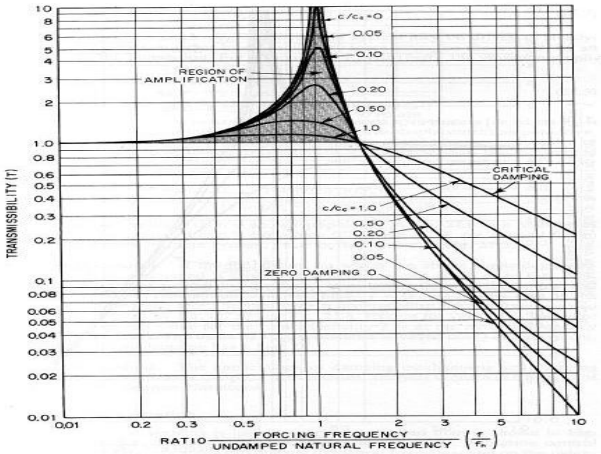

Fig.2 transmissibility chart [5]

$$T.R. = \frac{\sqrt{1+(2\zeta r)^2}}{\sqrt{(1-r^2)^2+(2\zeta r)^2}} \quad \ldots\ldots\ldots\ (1)$$

B. *Dimension specification*

For a machine footing different combination of structure are made. But all the dimensions are kept same for all composition, this dimensions are take with considering portable machines which are producing vibration without rigid foundation. The material dimensions are selected as:

Table 1. Material specification

Material	Length (mm)	Width (mm)	Thickness (mm)
M. S.	80	80	5
Cork	80	80	5
Rubber	80	80	10

C. *Composition of material*

The isolator are assemble at the bottom of machine, for that assembly four mounting pad are manufacture with different layer combination as,

Table 2. Combination of layer

Composition no.	Material sequence		
Composite 1	M. S.	RUBBER	
Composite2	M. S.	CORK	RUBBER
Composite 3	M. S.	RUBBER	CORK

D. Manufacturing process

As per the given dimensions of foundation, three materials are cut in to four pieces and finished with grinding wheel. The materials are stick one over another with the help of adhesive solution which is having good adhesion property.

Fig.3 Combination of M.S. cork and rubber

As the weight of machine is act on pads and to prevent it from compression, the materials are stick under the compression load. As in the review study, in some work, composite material are use as a secondary bed for machine and that material layers are bolted with each other [3].

VI. ANALYSIS BY ANSYS

The object is checked by the harmonic analysis on ANSYS software, for checking of material natural frequency. For analysis of it bottom surface is fixing and load over the top surface this boundary condition are used for the solution.

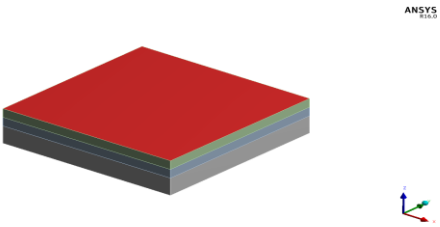

Fig. 4 Meshing of Composite

A. Graphical representation of composites

The natural frequency has been checked for the all type of composition with respect to amplitude and deformation of material under dynamic loading condition. As on the transmissibility graph the natural frequency should be lower than the forcing frequency [5]. So the ratio of forcing frequency to the natural frequency is must be lower. With these the vibration absorption rate is decreases otherwise the resonance is created in that structure if the natural frequency is intersecting the forcing frequency and extra noise will produces.

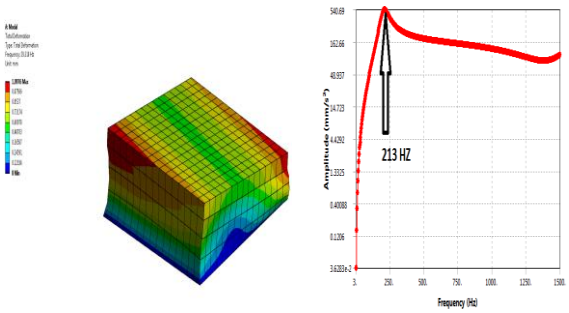

Fig. 5 Object deformation and natural frequency mode shape

B. Experimental checking on spectro dynamics machine.

The materials for isolators are bounded with the adhesive material, it has been necessary to sustain the dynamic loading, and not separated in working condition. For that checking composite is placed on spectral machine and it is excited with 5 to 100 Hz frequency with 19.81 m/sec^2 acceleration and the result are found out that there is no any crack or deformation found between intermediate of layer and by both the sensors it has been study that the isolator is having good vibration absorption property.

Fig. 6. Object on spectral dynamics

C. Experimental setup

The composite of M.S. CORK and RUBBER material are having the low natural frequency for high loading and by these property vibrations are absorbed by the material. For the sake of comparing the frequency of pad, experimental results have to be checking. For that setup of unbalanced reciprocating mechanism is made with motor and belt transmission system.

Fig. 7 Experimental setup

For experimentation FFT analyzer is use. The amount of vibration that machine is producing without any type isolation pad, and by using pads is being calculate by providing the signal receiving sensor at the top of the base plate and at the bottom of the isolator for all layers

VII. RESULTS

The results are calculated by the FFT analyzer on experimental setup for different combination of isolator and this result are compared with ANSYS result.

Table. 3 Experimental Results by FFT Analyzer

MACHINE FOUNDATION	SENSOR AT BOTTOM		SENSOR AT TOP	
	Velocity (mm/s)	Accl^n. (m/s^2)	Velocity (mm/s)	Accl^n. (m/s^2)
Without foundation	1.48	4.25	7.83	8.86
Composite 1	19.6	8.49	5.02	6.57
Composite 2	0.476	0.755	3.29	11.09
Composite 3	0.378	0.715	3.46	12.01

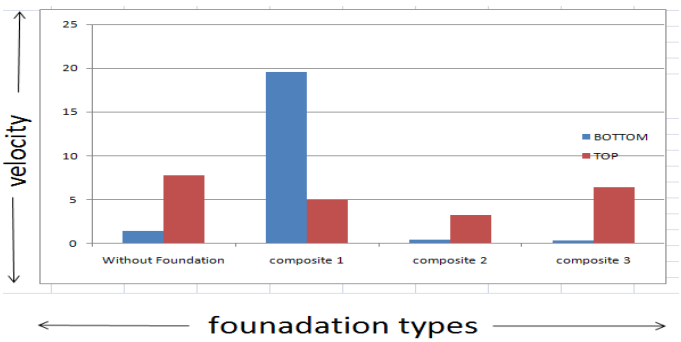

Fig.8 Transmissibility of foundation by FFT Analyzer

The following results are calculated by the software by providing sutaible boundary conditions for the all combinations of isolators

Table. 4 Frequency calculation for different mode shape by ANSYS.

parameter	Mode shape	Composite 1	Composite 2	Composite 3
Frequency (Hz)	1&2	85	29	33
	3	606	207	238
	4	3874	1688	1893
	5&6	4392	1890	2104

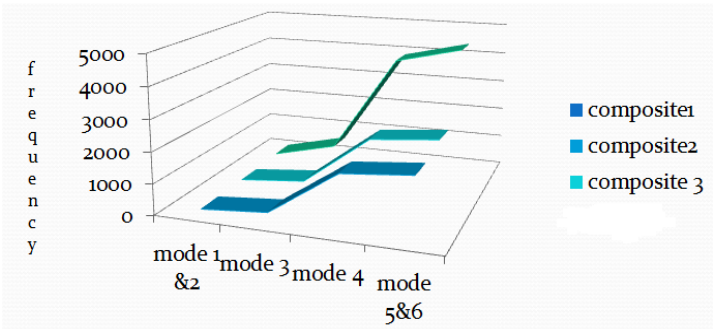

Fig. 9. Composite frequency graph

By analyzing all the composites, the natural frequency graph is plot and it indicates that, the composition 2 is having the low natural frequency. By the transmissibility graph, as the natural frequency of material is less than the forcing frequency, the ratio of it is in the limit of damping region.

VIII. CONCLUSION

By analyzing all the combination of isolators with the help of experimental setup and software analysis it is concluded that:

- The combination of M.S plate, cork and rubber are having minimum natural frequency as compare to other.
- By testing FFT analyzer the vibration absorption is also maximum by material, and the level of vibration at machine foundation and structure is also reduced.
- The deformation under the static loading condition is also minimum as compared to the other combination.

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