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*Review Article*

# A Review on Active, Semi-active and Passive Vibration Damping

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***Abstract***

*Undesired commotion and vibrations are since ever a noteworthy issue in numerous human exercises and domains. Airplanes, space trusses and satellites, cars, machine tools and large bridges, all can be disturbed in their normal functions by vibrations and noise. So to reduce vibrations there are various damping techniques which can be mainly categorized as active, Semi-active and passive damping. Among these active damping requires arrangement along with sensors which finally increases cost. On other hand passive damping can be easily combined with vibrating structure. Passive damping has various techniques such as viscous damping, viscoelastic damping etc. but each of it have certain limitations which may be environmental conditions or temperature varieties or connection with vibrating structure without changing its qualities (such as its stiffness, weight etc.).So recently developed particle impact damping (PID) is proving to be one of the techniques which overcome most of the limitations of above said. This paper focuses or discusses on the methods to reduce vibrations by using various damping techniques. Paper is a review of various literatures available on different types of vibration damping.*

***Keywords:*** *Vibration Damping, Viscous Damping, Particle Impact Damping, Vibration Isolators.*

## 1. Introduction

Vibration is a mechanical marvel whereby motions happen by a balance point. The oscillations may be periodic, such as the motion of a pendulum or random. In many practical systems, the vibrational energy is gradually converted to heat and sound. The mechanism by which the vibrational energy is gradually converted into heat and sound is known as damping. It is additionally said to be any impact that has a tendency to diminish the adequacy of vibration in an oscillatory framework.(Christophe Collette, 2011), Damping is an influence within or upon an oscillatory system that has the effect of reducing, restricting or preventing its oscillations, Dissipating some of the energy which is added to a dynamic system by exciting forces during each cycle of the response, also damping is active and passive damping techniques are common methods of attenuating the resonant vibrations excited in a structure. Active vibration damping strategies are not applicable under all conditions due, for instance, to power prerequisites, cost, environment, and so on. Under such conditions, passive damping strategies are a suitable option. Passive damping has many types as, viscous, viscoelastic, friction, and impact damping. Viscous and viscoelastic damping usually have a relatively strong dependence on temperature. Friction dampers, while applicable where wide temperature ranges, may downgrade with wear. Due to these limitations, attention has been focused on impact dampers, particularly for application in environments or at elevated temperatures. Particle damping innovation is a subordinate of impact damping with a few favorable circumstances. Particle dampers, also known as shot dampers or granular-fill dampers are passive damping devices. The innovation of particle damping is the losses of vibratory energy that occur during impact of granular particles which move freely within the boundaries of a cavity attached to a primary system.

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## 2. Types of Vibration Damping

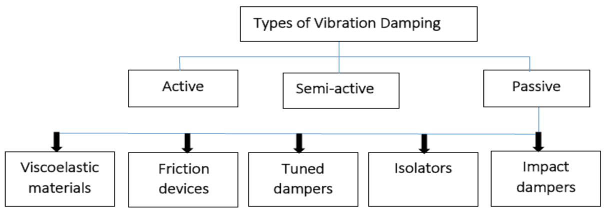



**Fig.1** Flow chart of vibration damping

To control vibration, they can be divided into three main categories, namely, active, semi-active, and passive vibration control illustrated in Fig. 1. Active and passive damping techniques are common methods of attenuating the resonant vibrations. Active vibration control systems depend on a power source. They require power for operating the sensors, senses the level of vibration, process the sensor signals by control systems and send driving signals, and the driving devices that apply forces to reduce the level of vibration. Active damping innovation is more complicated and costly than passive damping, require maintenance, and there is a higher possibility of failure. Passive vibration control systems function without external service; they are driven by the vibration itself, so not require power source. In most cases, they offer the simplest and reasonable solution to the problem. They require little or no maintenance, and Installation is relatively simple and low or no maintenance required. The typical example is a tuned mass damper, which consists of a mass-spring-damper system, is a common example for vibration absorbers that operate on the same principle. (T T Soong, 2000)

*2.1 Active Vibration Damping*

When the energy is removed from the system through feedback system in control system is known as active damping. The exerting of counter force or moment in a controlled manner by which we can achieve active damping. As the force is applied on the structure, the structure varies, the sensor senses the response. The controller receives signal and transmit signal to the control actuator. The actuator develops force or motion proportional to the command signal, it control desired motion of the structure. (S.S. Rao 2014).

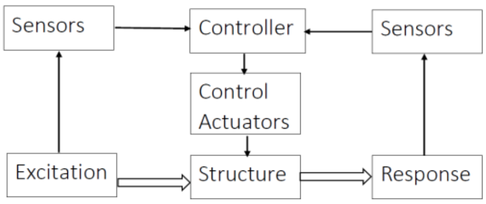



**Fig.2** Active vibration damping

Examples are vibration and shape control of flexible systems like optical mirror, Gitter control of high precision instruments, and Active suspension system for ride comfort in advanced vehicles.

*2.2 Semi- Active Vibration Damping*

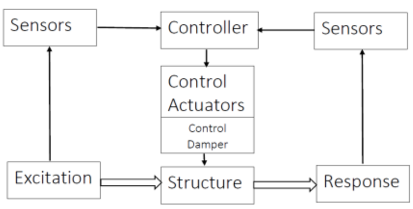



**Fig.3** Semi-active vibration damping

According to dynamic response, the semi active system changes structural properties of structures by using variable stiffness or variable damping system. In the semi-active system, indirectly control forces acting to control object, and control devices are driven by small power resources. Semi-active control system do not add energy to the structure and its properties can be varied dynamically.

Magnetorheological (MR) dampers, variable orifice dampers and tuned liquid dampers are examples of semi-active devices.

*2.3 Passive Vibration Damping*

They have different passive damping techniques as shown in Fig. 1.such as viscoelastic materials applications, friction devices, tuned dampers, isolators, impact dampers. However, this method depends on operating temperature. Viscoelastic materials have used for increasing damping in structures. Be that as it may, they lose their viability in low and high temperature situations and debase after some time. Hence there is a need of damping mechanism which can operate in harsh environment for a long period of time. The design of a robust passive damping technique particle impact damping offers the potential with insignificant on the strength, stiffness and weight of a structure. With an appropriate choice of particle materials (lead, steel), this technique is independent of temperature and is very durable. Also, this procedure is beneficial over single-particle effect dampers that experience the effect of actuated high noise levels and surface degenerations as well as high sensitivity to size of container and excitation input.

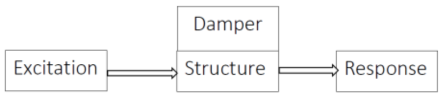



**Fig.4** Passive vibration damping

*Viscous Damping*

Viscous damping is the maximum generally used damping mechanism in vibration evaluation. Mechanical structures vibrate in a fluid medium which include air, gas, water and oil, the resistance supplied by the fluid to the shifting body reasons strength to be dissipated. In this case, the amount of energy dissipated depends on many factors such as shape and size, viscosity of fluid, frequency of vibration, and velocity of the vibrating body. The damping force is proportional to the velocity of the vibrating body. Typical examples of: fluid film between sliding surfaces, fluid film around a piston in a cylinder, fluid flow through orifice.

*Friction Damping*

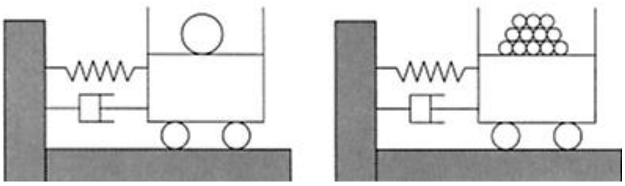
The damping force is constant in magnitude but opposite in direction to that of the motion of the vibrating body. It is caused by friction between rubbing surfaces that are either dry or have insufficient lubrication.

*Vibration Isolators*

It is a procedure by which the undesirable effects of vibration are reduced. A passive isolators consist of a resilient member (stiffness) and an energy dissipater (damping). Metal springs, cork, felt, pneumatic springs, and elastomer are the examples. In active isolators consist of servomechanism with a sensor, signal processor and actuator. (S.S. Rao 2014)

*Impact Dampers*

Particle impact damping is a method to increase structural damping by inserting particles in an enclosure attached to a vibrating structure. The particles take in kinetic energy of the structure and convert it into heat through inelastic collisions among the debris and the enclosure. Additional energy dissipation may also occur due to frictional losses and inelastic particle-to-particle collisions amongst the particles. The principle behind particle damping is the removal of vibratory energy through losses that occur during impact of granular particles moves freely through boundaries of a cavity into primary system. Particle damping with suitable materials can performed in a wider temperature range than most other forms of passive damping. Consequently, it could be applied in extreme temperature environments, wherein maximum conventional dampers could fail. The damping efficiency of particle damping depends on cavity dimensions whilst the most effective dimensions of the cavity are big, the most appropriate hollow space won't be connected from practical layout point of view In one of these case, the damper overall performance is retained when particle dampers are replaced by means of multi-unit dampers with a mild number of small cavities. Particle damping technology is a derivative of impact damping with several advantages. impact damping usually refers to only a single (somewhat larger) auxiliary mass in a cavity, whereas particle damping is used to imply multiple auxiliary masses of small size in a cavity.



**a)** Impact damper **b)** Particle damper

**Fig.5** Idealized single-degree-of-freedom system

## 3. Present Theories

**Christophe Collette *et al.*** reviewed recent patented developments in active vibration isolation. The fundamental limitations of passive vibration isolations were established in the first part. This is for the purpose of understanding the inspirations to announce active control in vibration isolation. Then, the simple systems are used to present important different active strategies for comparison. Finally, many detailed issues were listed and also discussed in short.

**Niu Hongpan** investigated vibration control of beam through electro-magnetic constrained layer damping (EMCLD) which consists of electromagnet layer, permanent magnet layer and viscoelastic damping layer. while the coil of the electromagnet is inspired with proper manage approach, the electromagnet can exert magnetic force opposite to the course of structural deformation, so that the structural vibration is attenuated A simulation on vibration control of a cantilever beam is conducted under the velocity proportional feedback to demonstrate the energy dissipation capability of EMCLD, and the beam system was experimented. The results indicate that the beam system has better control performance for larger control current. The EMCLD method presented in this paper provides an applicable and efficient tool for the vibration control of structures.

**Andrzej Weremczuk** presented an analysis of two-dimensional nonlinear model of milling. The analyzed model takes into account susceptibility of the tool and the workpiece. The dynamics of the milling technique is defined by means of the discontinuous differential equation with a time delay, which can cause method instability for numerous gadget parameters. Therefore, stability lobes diagram was determined. Numerically which will lessen harmful vibrations the idea of the usage of energetic piezo-elements is offered right here. In addition, the work shows numerical results of chatter control in open and closed loop.

**S.H Chen** presented a finite detail components for vibration manipulate and suppression of wise systems with a new piezoelectric plate element on the basis of a poor speed comments control law, a general method of active vibration control and suppression for intelligent structures was put forth. Dynamic stability and the effect of vibration control for intelligent structures were investigated by introducing the state space equations of intelligent structures. The damped frequencies as well as the damping ratio are derived by state space analysis. The procedure was illustrated with the help of two numerical examples. The first example is used to check the accuracy of the present finite element solution with the analytical one; the second instance is to take a look at the trouble of energetic vibration manipulate and suppression for sensible systems.

**Shaunak P Mhatre** throws light on advancement done in order to increase ride comfort of driver in an automobile. These road vibrations are measured in form of pulses and in step with it family members have been plotted against damping pressure required for stability of passenger seat. This work investigates propagation of shock pulses from road conditions by presentic different mathematical models of quarter car semi active suspension system, first studied the 2DOF system, which become then changed to a few ranges of freedom with fuzzy control of zone automobile gadget and afterwards, brought tiers of freedom device. A skyhook system was then introduced which used with two different sensors to measure two different masses. Eventually an important comparative have a look at changed into carried out at end of every version to compare performance traits of passive damping machine and semi active suspension system with MR damper hired to region car machine

**Sumedh Marathe** presented the suspension system is very crucial when considering the ride comfort of vehicle driver and passengers. Most of the studies these days are primarily based on using semi-active suspensions for vehicle suspension machine. A semi-active suspension with MR dampers is promising way of improving the ride comfort. It provided the various ways of enhancing the ride consolation the usage of diverse mathematical fashions, experimental paintings and gives an overall conclusion of why the use of a semi-active suspension gadget with MR dampers is better than the usage of a passive system or an active system

**Banna Kasemi** presented magneto rheological (MR) dampers are considered as excellent prospect to the vibration control in automotive engineering. To beat the influence from road disturbances many control algorithms have been developed and opted to manage the vibration of the automobile. In this study, the methodology adopted to get a control structure is based on the experimental results. Experiments have been conducted to establish the behavior of the MR damper. In this paper, the behavior of MR damper is studied and used in implementing vibration control. The force displacement and drive-speed response with varying present has been based for the MR damper. The drive for the upward movement and downward movement of damper piston is discovered growing with present and speed. In the cycle mode the combination of upward and downward motion of the piston, the force having hysteresis behavior is found increasing with current. Outcomes of this study serve to help in the modelling of MR damper for control uses.

**Yasunori Miyamori** stated that Vibration control is effective method to improve safety and serviceability on bridge structures. Recently, advanced control methods such as hybrid system and semi-active system are studied by several studies. Semi-active control system detains vibration of constructions by extra damping or stiffness, and this system can be driven by small power In this study, semi-active vibration manipulate analyses are carried out on a cable structure model and a steel tower model by means of using variable damping method. Given that it's difficult to design semi-active manage ideas by human experience, manipulate programs are optimized by way of using Genetic Algorithm (GA) from response power of structural model. From analytical outcome, semi-active control system has good control effects for seismic excitation. In consideration of practical use, semi-active control system has suitable applicability for vibration control on bridge structures.

**Pooja J. Waghmare** explained the vibration behavior of a conventional boring bar and a boring bar using passive techniques for vibration reduction. Work piece and tool vibration control has been a subject of primary position in manufacturing company. High thinness ratio is a reason for boring bar to be subjected to high amount of vibrations that accelerate the tool wear affecting the tool life, greater noise level and improved deviations. It was focused on various damping techniques such as passive damping systems using particle impact damping and Magneto-Rheological (MR) fluid for vibration reduction purpose. This also announces the mechanics of boring operation that affects the tool wear, surface roughness, noise and hence affects the efficiency. It was compared the results of boring bar using passive damping and the conventional tool on the basis of modal analysis of vibrating structure, and the test results.

**Dayanand Wadhwankar** focused on the behavior of a boring tool that arises under different overhang lengths which are commonly used in the manufacturing industry**.** Boring is a commonly used operation to increase the existing holes of machine structures. Boring tool is slender and long, it is exposed to extreme static deflections or a self-excited chatter vibration which decreases the accuracy and surface finish. It also affects accelerated wear and shaving of the tool. Internal turning frequently requires a long and slender boring tool in order to machine inside a hole, and the vibrations normally developed much connected with one of the fundamental bending modes of the boring tool. Use of passive Damper of different orientation reduces vibration level in Boring tool & tool holder &work piece to be enlarging hole improving surface finish.

**Daula.Paramesh** focused on unwanted vibration in machine tools like milling, lathe, grinding machine is one of the main problem as it affects the quality of the machined parts, tool life and noise throughout machining process. Hence these unsolicited vibrations are required to be repressed or damped out while machining For this reason the present work concentrates and goals on learn of extraordinary controllable parameter that impact the responses like vibration amplitude and roughness of machined phase. The part to be machined is kept on roll of plates made up of polymer and composite material. The roll alongside through the part to be machined is fixed on the slotted table of horizontal milling machine. Finite element analysis (FEA) was carried out to know the resonance frequencies at which the structure should not be excited.

**Vivek U. Sakhare and A.S. Aradhye** focused or discussed on the methods to reduce vibrations by using particle impact dampers. The damping performance of particle impact damper has been found highly nonlinear behavior. The vibration generates difficulties to the structure which reduces the structure life and increases the possibilities of failure to the structural. It was presented a review on research carried out on behavior of various parameters of particle impact damping. The methods like experimentation, analytical and discrete element method to validate results were used. Actual modelling of the experiment is done and using vibration exciter vibrations were given and readings were recorded by FFT analyser. Researchers have used the parameters like packing ratio, material of beam, material of fine particles and its size. Some researchers have focused on the design methodology of the particle damping, while experimentation beam was studied with particles and without particles. The particles were used like copper, aluminum, glass, sand, lead, tungsten carbides.

## Conclusions

We have studied different method of vibration damping with suitable example.

1) In active vibration damping depend on a power source mostly more complex and expensive than passive systems, require maintenance, and there is a higher possibility of failure.

2) Semi-active vibration is intermediate between active and passive. The drawbacks are removed by means of semi-active system which presents comparable overall performance to energetic suspensions but without the high value.

3) Passive damping can be easily combined with vibrating structure. It can be easily combined with vibrating structure with least modification of structure stiffness, weight etc. and such various benefits over other damping techniques

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