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VIBRATION CONTROL BY USING PARTICLE DAMPER

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Abstract— Vibration is the most considerable domain in industries now a day. Particle damping (PD) is a means for achieving high-structural damping by the use of a particle filled enclosure attached to the structure in a region of high displacements. The particles absorb kinetic energy of the structure and convert it into heat through in elastic collisions between the particles and the enclosure, and among-st the particles. In this work, PD is measured for a cantilevered aluminum beam with the damping enclosure attached to its free end; Steel particles are used in this study. The effect of acceleration, amplitude and clearance inside the enclosure on PD is studied. Additional energy dissipation can also occur due to frictional losses and in elastic particle-to-particle collisions. The unique aspect of PD is that high damping is achieved by absorbing the kinetic energy of the structure as opposed to the more traditional methods of damping where the elastic strain energy stored in the structure is converted to heat. Particle impact damping offers the potential for the design of an extremely robust passive damping technique with minimal impact on the strength, stillness and weight of a structure. Particle impact damping offers the potential for the design of an extremely robust passive damping technique with minimal impact on the strength, stillness and weight of a structure.
Keywords - Vibration, Damping, PD.

INTRODUCTION

Vibration is a mechanical phenomenon whereby oscillations occur about an equilibrium point. The word comes from Latin vibrational ("shaking, brandishing"). The oscillations may be periodic, such as the motion of a pendulum—or random, such as the movement of a tire on a gravel road. Vibration can be desirable: for example, the motion of a 'tuning fork', the reed in a woodwind instrument or harmonica, a mobile phone, or the 'cone of a loudspeaker'. [1] In many cases, however, vibration is undesirable, wasting energy and creating unwanted sound. For example, the vibrational motions of Engines, electric motors, or any mechanical device in operation are typically unwanted. Such vibrations could be caused by imbalances in the rotating parts, uneven friction, or the meshing of gear teeth. Careful designs usually minimize unwanted vibrations. The studies of sound and vibration are closely related. Sound, or pressure waves, are generated by vibrating structures (e.g. vocal cords); these pressure waves can also induce the vibration of structures (e.g. ear drum). Hence, attempts to reduce noise are often related to issues of vibration. [1]

Types of vibration:

Free vibration, occurs when a mechanical system is set in motion with an initial input and allowed to vibrate freely. Examples of this type of vibration are pulling a child back on a swing and letting it go, or hitting a tuning fork and letting it ring. The mechanical system vibrates at one or more of its natural frequencies and damps down to motionlessness. [2]
Forced vibration, is when a time-varying disturbance (load, displacement or velocity) is applied to a

mechanical system. The disturbance can be a periodic and steady-state input, a transient input, or a random input. The periodic input can be a harmonic or a non-harmonic disturbance. Examples of these types of vibration include a washing machine shaking due to an imbalance, transportation vibration caused by an engine or uneven road, or the vibration of a building during an earthquake. For linear systems, the frequency of the steady-state vibration response resulting from the application of a periodic, harmonic input is equal to the frequency of the applied force or motion, with the response magnitude being dependent on the actual mechanical system. [2]

Damped vibration: When the energy of a vibrating system is gradually dissipated by friction and other resistances, the vibrations are said to be damped. The vibrations gradually reduce or change in frequency or intensity or cease and the system rests in its equilibrium position. An example of this type of vibration is the vehicular suspension dampened by the shock absorber. [2]

Active and passive damping techniques are common methods of attenuating the resonant vibrations excited in a structure. Active damping techniques are not applicable under all circumstances due, for example, to power requirements, cost, environment, etc. Under such circumstances, passive damping techniques are a viable alternative. Various forms of passive damping exist, including viscous damping, viscoelastic damping, friction damping, and impact damping. Viscous and viscoelastic damping usually have a relatively strong dependence on temperature. Friction dampers, while applicable over wide temperature ranges, may degrade with wear. Due to these limitations, attention has been focused on impact dampers, particularly for application in cryogenic environments or at elevated temperatures. [2]

Particle damping technology is a derivative of impact damping with several advantages. Impact damping 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. The principle behind particle damping is the removal of vibratory energy through losses that occur during impact of granular particles which move freely within the boundaries of a cavity attached to a primary system. In practice, particle dampers are highly nonlinear dampers whose energy dissipation, or damping, is derived from a combination of loss mechanisms, including friction and momentum exchange. Because of the ability of particle dampers to perform through a wide range of temperatures and frequencies and survive for a longer life, they have been used in applications such as the weightless environments of outer space, in aircraft structures, to attenuate vibrations of civil structures, and even in tennis rackets. [3]

Particle damping is a type of impact damping where multiple particles are placed inside the cavity of vibrating structures. Studies conducted recently have shown the effectiveness and potential application of particle dampers. Particle damping is used to increase structural damping by filling particles in an enclosure attached to the vibrating structure. The unique feature of this type of damping is that high damping is achieved by converting kinetic energy of the structure to heat as opposed to the more conventional methods of damping, where the elastic strain energy stored in the structure is dissipated into heat. The particles absorb kinetic energy of the vibrating structure and convert it into heat through inelastic collisions among the particles and between the particles and the enclosure. It involves the potential of strain energy absorption and dissipation of the same through momentum exchange between moving particles and vibrating walls, friction, impact restitution, and shear deformation. [3]

METHODOLOGY

Initially, the literature survey about our topic that is use of particle damping will be carried out. From literature survey the best combination of particles and effect of vibration on manufacturing process will be considered. Effect of Various Parameters on Machining Operation with and without Particles.

A. According to machining process parameters.

In the present work following parameters of interest are decided to be considered during experimental study. The experimentation work will be carried out on the lathe machine in workshop of our institute.

I. Speed – The cutting speed has a great influence on tool life. It is observed that with the increase in the cutting speed tool life goes on decreasing. Tool wear also get increased with increasing the cutting speed which intern affects the tool life.

II. Feed – In this experimentation the machine used during testing was ordinary lathe having lead screw of fixed pitch which was facilitating constant feed rate. However, earlier researchers have reported that the increase in feed rate also affects tool life.

B. According to nature of particle.

I. Size – To achieve the damping effect, it was planned initially to use particles of different metals in tool holder. However, while using the lead and copper particles of high density in tool holder a special permission was needed from various government departments since they are used in making explosives. Therefore idea of using lead and copper particles was dropped and instead stainless-steel particles were chosen as per the market availability.

II. Packing Ratio – While achieving the damping using particles of different sizes another aspect also come into picture which is in the form of packing volume fraction of particles filled into the cavity of boring bar. There were chances of getting different values damping with different packing volume fractions. Therefore it was decided to carryout experimentation with different packing ratios to understand the effect of packing ratios with damping achieved from the tool holder with particles.

III. Shape: Shape of material is selected based on the packing ratio for which particles can be easily full fill inside the enclosure.

IV. Material: For the same particles are available with various range and materials such as Lead particles; Tungsten carbide particles are way more effective than any other materials used for Particle damper. But such materials are already had a big use in the armory for explosives, hence these two materials are very hard to get and need permissions from various departments of government. Hence, we will try to use the Steel or steel carbide particles which will have more mass density.

II. Modal analysis of boring bar using 'ANSYS'

The modal analysis is used to determine structural vibration characteristics like natural frequencies and mode shapes. It is the most fundamental of all the dynamic analysis type. The main objectives of modal analysis are, it allows the design to avoid resonant vibrations or to vibrate at a specified frequency and it gives engineers an idea of how the design will respond to different types of dynamic loads. The modal analysis of boring bar with various packing ratio of particle and without particle was carried out.

Modal analysis of boring bar was done by using ANSYS Workbench software. For the experimentation it is decided to adopt well known Taguchi's Design of Experiment technique.

There are various standardized and well established methods of doing analysis which helps in analyzing the system with minimum work and time.

Taguchi methods are statistical methods, or sometimes called robust design methods, developed by Genichi Taguchi to improve the quality of manufactured goods, and more recently also applied to Engineering, Bio-tech advertising. Professional statisticians have welcomed the goals and improvements brought about by Taguchi methods, particularly by Taguchi's development of designs for studying variation, but have criticized the inefficiency of some of Taguchi's proposals. Taguchi realized that the best opportunity to eliminate variation of the final product quality is during the design of a product and its manufacturing process. Consequently, he developed a strategy for quality engineering that can be used in both contexts.

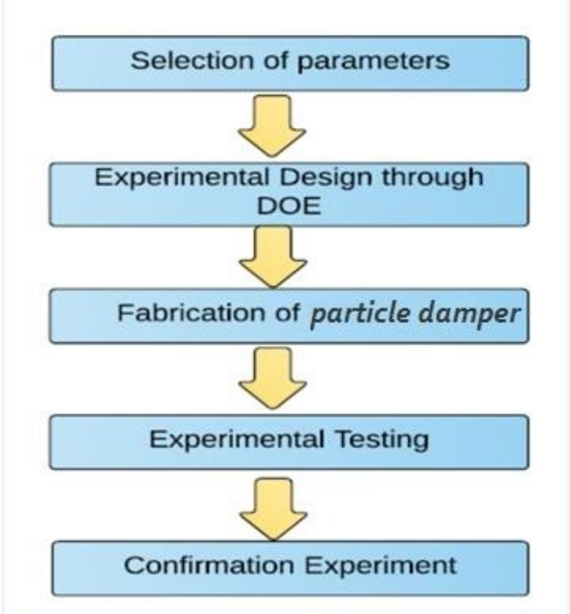

Fig 1: Adopted Methodology

a. Acceleration measurements by using piezoelectric sensor interfacing with Arduino Uno R3.
b. Piezoelectric sensor interfacing with Arduino Uno R3, this is a student level project based on Arduino Uno R3 and piezoelectric sensor.

c. Piezoelectric sensor is basically a transducer which converts stress applied on it into some electrical energy. It is simply used the principle of energy conversion from one form to another. As in case of piezoelectric sensor, it converts physical stress into electrical energy. Stress can be a force, pressure, acceleration and touching potential. Because these all are kind of stresses and piezoelectric sensor converts such kind of physical forces into electrical form.

d. Larger, as a minor reduction in size should not have an adverse effect the quality of the image.

EXPERIMENTATION

In this work it is planned to study the vibrations levels of system with particle damper. This type of experimental set up will be fabricated in 1st phase of this work.
In the 2nd phase of this proposed work, vibration signatures will be acquired through sensors and data acquisition system and these results will be studied and analyzed further to get more insight in to the problem under study. We measure the frequencies of the system with and without particle damper by using FEA tool.In the 3rd phase of this proposed work these results will be summarized to come to final conclusion.
1. Particle damper analysis with FEA tool
Because of its diversity and the finite element method is numerical analysis technique for obtaining approximate solutions to a wide variety of engineering problems. Flexibility as an analysis tool, it is receiving much attention in almost every industry. It is not possible to obtain analytical mathematical solutions for many engineering problems. The finite element method has become a powerful tool for the numerical solutions of a wide range of engineering problems. It has been developed simultaneously with the increasing use of the high-speed electronic digital computers and with the growing emphasis on numerical methods for engineering analysis.

2. Preparation of Test Set Up
On the basis of literature review test set up with particle damper will be prepared as follows,

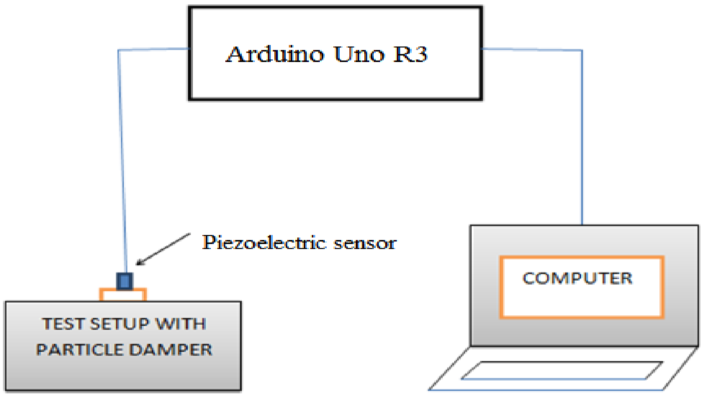

Fig 2: Proposed Schematic Experimental Test Set Up

3. Data Acquisition and Analysis

The accelerometer at the point mass will record data for future analysis. The data from the accelerometer will be analyzed and saved within National Instrument's Lab-View program. The input vibration will be controlled via a pre-compiled routine and will be used to format the data into Response vs. Input plots. With the collection of all data, plots of each result will be created to visually determine the relationships between particle properties and the resultant responses.

CONCLUSION

The particles of the PD are the key factor in achieving the maximum damping effect. The performance of a particle damper the forced vibrations of structures were investigated under random excitation. Results from testing different types of particles indicated that the frequency at which maximum damping occurs and the amount of damping obtained depend on properties of the particles. The amount of damping due to the friction effect is smaller than that of the impact effect.

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