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# EXPERIMENTAL ANALYSIS OF VIBRATION IN MACHINE TOOL BEDS

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**ABSTRACT**

When machine is functioning then generate the vibration and vibrate the tool bed and from this vibration reduce the productivity .Basically machine toll structures like drilling machine, grinding machine, lathe machine, broaching machines are subjected to regular unwanted vibrations. When generate the vibration in machine beds, it results in bad quality on machined parts, unwanted noise, destroy the toll life. From this reasons diminish the productivity.

In the present experimental work diminish the vibration by the use of composite fiber materials and fiber epoxy in the form of composite structure. Here Carbon Fiber Polyester and Carbon Fiber Epoxy plates are fixed on to the slotted table as a secondary bed material and the work piece will mount on this bed for feeding to the rotating milling cutter. Further four holes were drill on each plate of the composite and sated of five plates of each type of composite is mounting for conducting the experiment. A mild steel sample of equal dimension of the carbon composite plate is placed on the pile of the composites. The setup fixed to the slotted table by using nuts and bolts. An up milling operation operated and here vibration signal recorded on the screen of the digital phosphorus storage oscilloscope. The signal frequency, RMS amplitude and time period of vibrations are recorded. This experiment was done repeat for different sets of composite plates by decreasing the number and the related readings are recorded and tabulated. Moreover, experiments were also conduct without any composite material beneath the mild steel specimen. In this experiment founded that the vibration amplitude decreases with increases in number of layers of sheets of composites and then increases with increase in number of plates

**Keywords:** Carbon fiber, Carbon fiber epoxy, mild steel plate, Amplitude, layers of sheets, Vibration.

**1.1 Introduction**:

Most of the person activities involve vibration in one form or other form. We can see for example we hear since our eardrums vibrate and observe because very light waves undergo vibration. Any movement that repeats itself after a period of time is called vibration or oscillation. The general terms of “Vibration” is used to explain oscillatory motion of mechanical and structural systems The Vibration of a system involve the move of its potential energy to kinetic energy and these kinetic energy to potential energy alternately .Anything in this earth having mass and elasticity is capable of vibration .We are mainly focused in vibration of mechanical system .When

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subjected to an oscillating load this system undergo a vibratory performance .Vibrations are an engineering apprehension in these application since they may cause a disastrous failure (complete collapse) of the machine or structure because of too much stresses and amplitudes or because of material fatigue over a period of time. Example: - Failure of Tacoma Narrows Bridge in 1940 due to 42-mile-per-hour wind undergoing a torsion mode resonance .Vibration of machine apparatus generates annoying noise. Vibration of string generates pleasing music. A vibration in mechanical system is dissipating by inherent damping of the material. Vibration of mechanical system is replica as a combination of spring-mass-damper.

### 1.2 Machine Tool

Machine ToolStructure must possess high damping, high static and dynamic stiffness. In fact, general purpose machine tools, CNC lathes and machining centers are designed to cope with low cutting speeds with high cutting forces as well as high cutting speeds with low cutting forces. High cutting speeds and feeds are essential requirements of a machine tool structure to accomplish this basic function. Therefore, the material for the machine tool structure should have high static stiffness and damping in its property to improve both the static and dynamic performance.

The chatter is a nuisance to the metal cutting process and can occur on any chip producing tool. Chatter or Self-excited vibrations occurs when the width of cut or cutting speed exceeds the stability limit of the machine tool When the machine tool is operated without any vibration or chatter, the damping of the machine tool plays no important role in machining. However, the machine tool structure has several resonant frequencies because of its continuous structural elements.

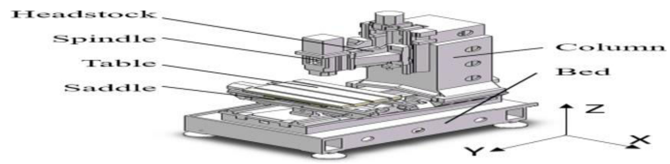


Fig. 1.1 Machine Tool Structure

### 2.1 Composite Materials –

Over the last thirty years composite materials, plastics and ceramics have been the dominant emerging materials. The volume and number of applications of composite materials have grown steadily, penetrating and conquering new markets relentlessly. Modern composite materials constitute a significant proportion of the engineered materials market ranging from everyday products to sophisticated niche applications.

### 2.2 Classification of Composite Materials


Fig.2.1 Classification of composite material

### 2.3 Composites Used In The Work Are Carbon Fiber Epoxy And Carbon Fiber Polyester.

Fiber carbon is made from extremely fine fibers of carbon. It is used as a reinforcing agent for many polymer products; the resulting composite material, properly known as fiber-reinforced polymer (FRP) or carbon-reinforced plastic (CRP), is called "fiber carbon" in popular usage. Uses for regular fiber carbon include mats, thermal insulation, electrical insulation, reinforcement of various materials, tent poles, sound absorption, heat- and corrosion-resistant fabrics, high-strength fabrics, pole vault poles, arrows, bows and crossbows, translucent roofing panels, automobile bodies, hockey sticks, surfboards, boat hulls, and paper honeycomb. Epoxy is a thermosetting polymer formed from reaction of an epoxy "resin" with polyamine "hardener". Epoxy has a wide range of applications, including fiber-reinforced plastic materials and general purpose adhesives.

**3.1 Literature Review –**

A lot of literatures have been published on vibration damping. Vivek et al. 2016 -Recent trend in research shows that polymer composites are replacing cast iron and steel as they provide improved damping accompanied with comparable stiffness and strength. Among all the polymer composites, polymer concrete has found to be the promising material. This study presents a literature survey on polymer concrete for machine tool structural application. Cast iron, steel and other conventional materials are compared with polymer concrete. The review summarizes the research findings reported by different authors by using polymer concrete in different types of machine tool structures. Different varieties of particulate reinforcement, matrix and other fillers, reported in literatures are studied as to understand their influence on final properties of polymer concrete for machine tool structures.Lazans et al1968- Lazan's book published in 1968 gave a very good review on damping research work, discussed different mechanisms and forms of damping, and studied damping at both the microscopic and macroscopic levels . Lazan conducted comprehensive studies into the general nature of material damping and presented damping results data for almost 2000 materials and test conditions. Lazan's results show that the logarithmic decrement values increase with dynamic stress, i.e., with vibration amplitude, where material damping is the dominant mechanism. This book is also valuable as a handbook because it contains more than 50 pages of data on damping properties of various materials, including metals, alloys, polymers, composites, glass, stone, natural crystals, particle-type materials, and fluids. Nashif et al. 1985- About 20 years later, Nashif, Jones and Henderson published another comprehensive book on vibration damping. Jones himself wrote a handbook especially on visco-elastic damping 15 years later. N.okubo et al.1982 **-**Machine tool structure can be improved by model analysis and dynamic rigidity of machine tool. Basically this technique were applied on to a machining cell, an arm of automatic assembling machine and a conventional cylindrical grinder. By the use of advanced software's can be predict the quantitative improvement in the dynamic rigidity. The example on a NC lathe machine, vertical milling machine ,surface grinder show effectiveness of the software approach in suppress the chatter and enhance the surface finish. also the cutting test was verified the predicted improvement. C.T. Sun et al ,1985 **-**This paper describes an analytical study to optimize the internal damping of short fiber polymer matrix composites. Two different analytical methods-force balance model and finite-element numerical scheme were used to obtain numerical results. The loss factor is optimized in terms of many important parameters such as; fiber aspect ratio, the angle 13 between the applied tensile load and the fiber direction, stiffness ratio between the fiber and matrix materials and the damping ratio between the fiber and matrix materials. The numerical results show that, for given fiber and matrix materials and given fiber volume fraction, there exists an optimum fiber aspect ratio and an optimum angle 8 for maximum damping of the composite. The predicted optimum aspect ratios lie in the range of actual aspect ratios for whiskers and microfibers for small fiber damping and increases as the damping ratio between the fiber and matrix increases. The predicted optimum angle 8

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lies between 0 and 30”.Sun,C.T. et al 1995 Sun and Lu's book published in 1995- presents recent research accomplishments on vibration damping in beams, plates, rings, and shells . Finite element models on damping treatment are also summarized in this book. There is also other good literature available on vibration damping [11-13].Damping in vibrating mechanical systems has been subdivided into two classes: Material damping and system damping, depending on the main routes of energy dissipation. Coulomb (1784) postulated that material damping arises due to interfacial friction between the grain boundaries of the material under dynamic condition. Further studies on material damping have been made by Robertson and Yorgiadis (1946), Demer (1956), Lazan (1968) and Birchak (1977). System damping arises from slip and other boundary shear effects at mating surfaces, interfaces or joints between distinguishable parts. Murty (1971) established that the energy dissipated at the support is very small compared to material damping.Nashif et al. 1985 - had done survey on the damping capacity of fiber reinforced composites and found out that composite materials generally exhibit higher damping than structural metallic materials.

**4.1 Objective of the Research Work**

(1) The main objective of the work is to study passive damping techniques in machine tool structures using composite materials and to reduce vibrations in the milling machine during cutting processes by using these materials as the base of the work piece which act like a bed absorbing vibration forces and record the vibration curves using digital storage phosphorous oscilloscope.

(2) Composites can be used in machine tool structures because of its inherent damping characteristics which reducesthe undesirable effects of the vibrations.

(3) Passive damping technology has a wide variety of engineering applications, including bridges, engine mounts, and machine components such as rotating shafts, component vibration isolation, novel spring designs which incorporate damping without the use of traditional dashpots or shock absorbers, and structural supports.

**5.1 Introduction of Milling Machine**

Device that rotates by a circular tool that has a number of cutting edges symmetrically connect about its axis, work piece is commonly held in vise and similar device clamped to a table that can move in 3 perpendicular directions. Milling machines are often classed in two basic forms, horizontal and vertical, which refers to the orientation of the main spindle. Both types range in size from small, bench-mounted devices to room-sized machines. Unlike a drill press, which holds the work piece stationary as the drill moves axially to penetrate the material, milling machines also move the workpiece radially against the rotating milling cutter, which cuts on its sides as well as its tip. Workpiece and cutter movement are precisely controlled to less than 0.001 in (0.025 mm), usually by means of precision ground slides and lead screws or analogous technology. Milling machines may be manually operated, mechanically automated, or digitally automated via computer numerical control (CNC).

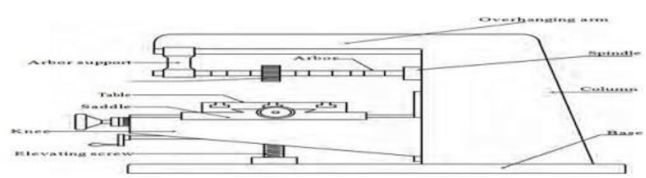


Fig 4.1 Horizontal Knee and column Milling Machine

**5.2 Vibration in Machine Tools**

The Machine, cutting tool, and work piece from a structural system have complicated dynamic characteristics. Under certain condition vibrations of the structural system may occur, and as with all types of machinery, these vibrations may be divided into two basic types:

1. Free or Transient vibrations: resulting from impulses transferred to the structure through its foundation, from rapid reversals of reciprocating masses, such as machine tables, or from theinitial engagement of cutting tools

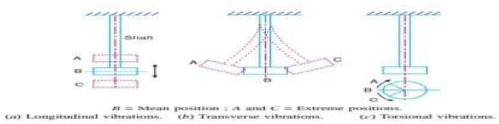

Fig 4.4: Free Vibration

2. Forced vibration: resulting from periodic forces within the system, such as unbalanced rotating masses or the intermittent engagement of multi tooth cutters (milling), or transmitted through the foundations from nearby machinery. The machine tool will oscillate at the forcing frequency, and if this frequency corresponds to one of the natural frequency of the structure, the machine will resonate in the corresponding natural mode of vibration.


Fig 4.5. Forced vibration

The sources of vibration excitation in a machine tool structure are vibration due to in- homogeneities in the work piece , cross sectional variation of removed material, disturbances in the vibration of tool drives , rotation unbalanced members guide ways , gears, drive mechanisms and others .

**5.3 Chatter in the Milling machine**

The mode coupling chatter occurs when forced vibrations are present in two directions in the plane of cut. The regenerative chatter is a self excitation mechanism associated with the phase shift between vibrations waves left on both sides of the chip and happens earlier than the mode coupling chatter in most machining cases.

Treating the mass as a free body and applying Newton's second law, the total force $F_{tot}$ on the body

Table 5.1 Typical damping values of different materials

**6.1 Experimental set-up**

| Systems/Materials | Loss Factor |
|---|---|
| Welded Metal structure | 0.0001 to 0.001 |
| Bolted Metal structure | 0.001 to 0.01 |
| Aluminium | 0.0001 |
| Brass, Bronze | 0.001 |
| Beryllium | 0.002 |
| Carbon | 0.002 |
| Lead | 0.5 to 0.002 |
| Steel | 0.0001 |

**Table 6.1 Specimen Details**

| S.No | Name of the Material | Cross section (mm) |
|---|---|---|
| 1 | Carbon Fiber Polyester | 210x210x6 |
| 2 | Carbon Fiber Epoxy | 210x210x5 |
| 3 | Mild steel | 210x210x10 |

Fig . 6.1. Carbon fiber polyester, carbon fiber epoxy and mild steel plate.

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### 6.2 Instrumentation

The following equipment is needed in recording the amplitude, frequency, period of the vibrationsduring the machining operation

(1) Digital Storage Oscilloscope (2) Vibration pick-up (3) Power supply unit

Fig.6.2 Digital storage oscilloscope, Vibration pick – up, Power supply unit

### 6.3 Experimental procedure

The dimension of specimen was taken 210 mm x 210 mm x10 mm is a mild steel square plate. After taken the specimen, four holes of 18 mm diameter are drilled on the specimen at the corners. The carbon fiber epoxy and polyester composite plates are thoroughly cleaned and polished. Plates were done fixed on to a bench vice and the edges are filed to clear off the irregularities. All the plates are made to the exact dimensions for the ease of the further operations. Four holes are drilled on each plate and these holes are needed to be coaxial when the plates are placed upon one another and also with the mild steel. A right hand cut two- flutes drill bit of size 18 mm is used to make holes. All the plates are carefully made homogenously similar to avoid interfacial vibrations and slipping. The work piece is then mounted onto the layered sheets of composites and tightly bolted to slotted table of the milling machine using square head bolts. Initially five carbon fiber polyester plates each of 6 mm thickness are placed upon the bed along with mild steel. A contact type magnetic base vibration pickup connected to a digital phosphor storage oscilloscope of Tektronix 4000 series is placed on the mild steel during the machining operation. The response signals with respect to amplitude, time period, RMS amplitude and frequency are recorded and stored on the screen of the storage oscilloscope. Then the numbers of layers are reduced to four layers and the observations are recorded. In this way, the experiments are repeated by decreasing the number of layers of various composites. The experiments are conducted for 5,4,3,2,1 number of layers respectively. The whole process is again repeated using carbon fiber epoxy plates each of 5 mm thickness and also with the Sandwich plates (both fiber epoxy and polyester) combination of 10,8,6,4,2 layers respectively. Finally mild steel plate alone is machined with no layer under it and the readings are noted and compared. An Up milling cutting operation with constant feed of 16mm/min and depth of cut of 0.02mm is performed during all the experiments. An oil-water emulsion made from animal fat is used as acutting fluid.

Fig 6.5.Five layers of Carbon fiber polyester bolted to the slotted table milling machine

Fig 6.6 Four layers of Carbon fiber polyester bolted to the slotted table milling machine

Fig 6.7 Three layers of Carbon fiber polyester bolted to the slotted table milling machine.

Fig 6.8 Two layers of Carbon fiber polyester bolted to the slotted table milling machine

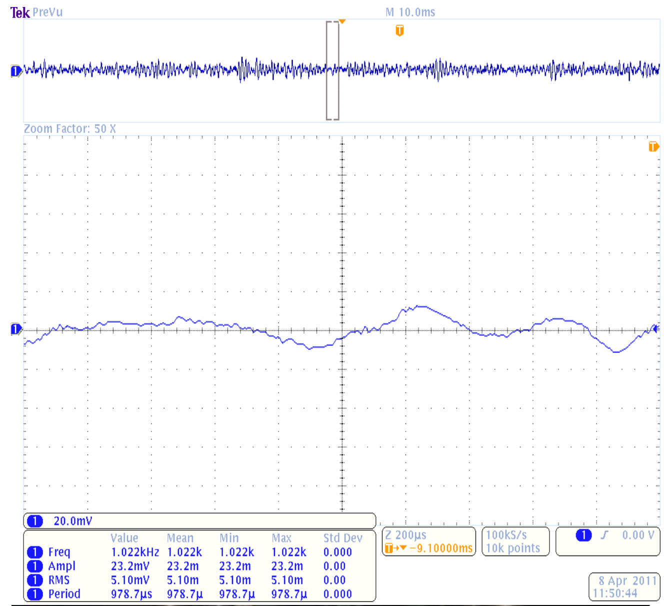


Fig 6.9 one layers of Carbon fiber polyester bolted to the slotted table milling machine

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### 7.1 Experimental Results

Table 7.1 Experimental Frequency and Amplitude data for Carbon fiber polyester

Fig 7.3 Vibration signal for three layers of Carbon fiber polyester plates

| S.N. | Depth of cut (mm) | Feed rate (mm/min) | Number of layers | Signal Amplitude(mV) | Time Period(µs) | Frequency (KHz) | RMS Amplitude(mV) |
|---|---|---|---|---|---|---|---|
| 1 | 0.03 | 15 | 5 | 49.6 | 292.0 | 3.425 | 9.99 |
| 2 | 0.03 | 15 | 4 | 46.4 | 339.0 | 2.786 | 10.2 |
| 3 | 0.03 | 15 | 3 | 23.2 | 978.7 | 1.022 | 5.10 |
| 4 | 0.03 | 15 | 2 | 30.4 | 510.0 | 1.961 | 6.75 |
| 5 | 0.03 | 15 | 1 | 52.4 | 902.5 | 1.108 | 13.4 |

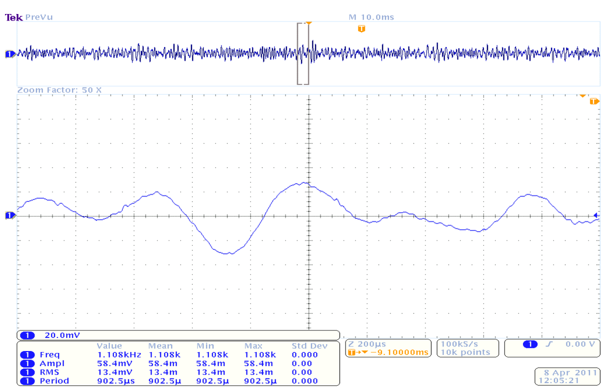

Fig 7.1 Vibration signal for five layers of Carbon fiber polyester plates

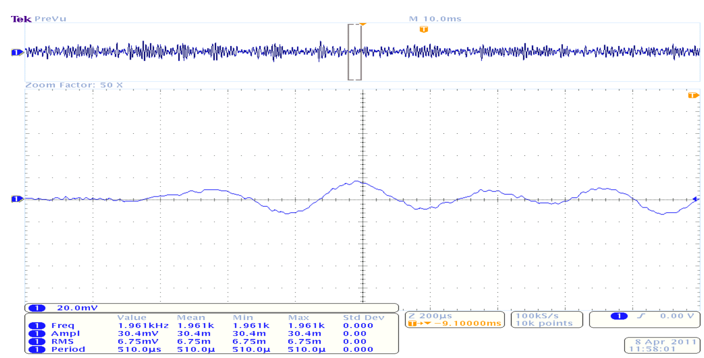

Fig 7.4 Vibration signal for two layers of Carbon fiber polyester plates

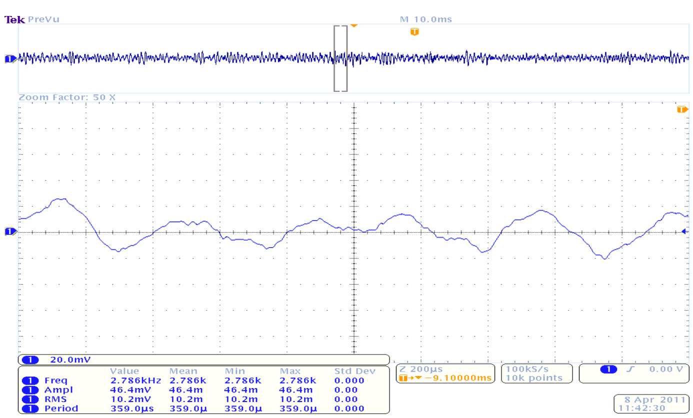

Fig 7.2 Vibration signal for four layers of Carbon fiber polyester plates

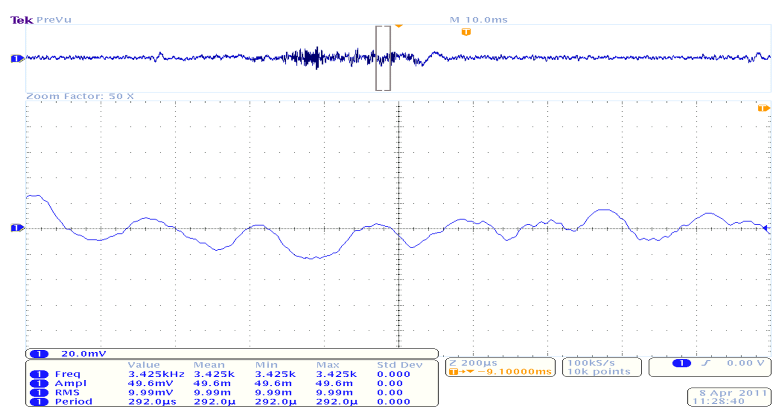

Fig 7.5 Vibration signal for single layer of carbon fiber.

**7.2 Result Discussions**

(1) From the above graphs show that the variation of signal amplitude with respect to number of layers of plate for various combinations of composites.

(2) It was found that when the numbers of layers are increased, the signal amplitude was decrease for both the composites to a certain extent and then increased abruptly.

(3).Here was observed that with increase the number of plates the damping can be increased but only to a definite limit and When it increase maximum limit then it would have a negative effect. Hence desire level of plates is to be decided to profitably damp out the vibrations. This optimum number of plates is different for carbon fiber polyester and carbon fiber epoxy.

**7.3 CONCLUSION**

1) Here was use carbon fiber and its epoxy for the reducing of vibration.

2) By the Use of composite materials decrease the vibrations of the system as desire which was justify from the various experimental observations.

3) When increase number of layers of composite at optimum levels then reduce the vibration.

4) On the different the optimum number of plates is decided and a one plate of desire thickness is used as the bed material.

**7.4 FUTURE SCOPE-**

(1) Present work can be extending by the use of different types of fiber such as E-glass fiber, Kevlar fiber, boron fiber etc for reducing the vibration.

(2) This experimental work may also be done in drilling machine, grinding machine, lathe machine etc.

(3) By the use of testing of suitable damping materials for structures according to the design necessities one can use the findings of the present work in different vibration problems.

(4) Experimental technique used in these details can be applied to achieve vibration isolation in different machine tool structure.

**7.5 REFRENCES**

1.Vivek A , Vijaya Holla , M.S.Krupashankara ‘Polymer Concretes for Machine Tool Structures – A Review “ IJIRSET Vol. 5, Issue 10, October 2016.

2.The Machine Tool Industry Research Association, A Dynamic Performance Test for Lathes,July, 1-86, (1971).

3.Welbourn, D.B. and Smith, J.D., “Machine Tool Dynamics, Cambridge University Press,Chap.1, Chap.5, Chap.8, (1970).

4.Koenigsberger, F. and Tlusty, J., “Machine Tool Structures”, Pergamon Press, Vol.1,Sect .2, (1970).

5.Cook, N.H., “Manufacturing Analysis, Addison-Wesley Publishing Company, Chap.3,Chap.7., (1986).

6.Merritt, H.E., “Theory of Self-Excited Machine Tool Chatter”, Journal of Engineering forIndustry, Transactions of ASME, 447-454 (1965).

7.Ruzicka, J. E., “Structural Damping”. ASME, New Jersey (1959).

8.Lazan, B. J., “Damping of Materials and Members in Structural Mechanics”. Pergamon Press,London (1968).

9.Nashif, A. D., Jones, D. I. G. and Henderson, J. P., “Vibration Damping”. John Wiley &Sons, Inc., New York (1985).

10.Jones, D. I. G., “Handbook of Viscoelastic Vibration Damping”. John Wiley & Sons, Inc.,New York (2001).

11.Sun, C. T., Lu, Y. P., “Vibration Damping of Structural Elements”. Prentice Hall PTR,Englewood Cliffs, NJ , (1995)