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VIBRATION DAMPING OF MACHINE TOOL STRUCTURE USING COMPOSITE MATERIAL

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ABSTRACT

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 during machining operation. Hence these unwanted vibrations are needed to be suppressed or damped out while machining. The important characteristics of the machine tool structures for metal cutting are high damping and static stiffness which ensure manufacture of work pieces of the required geometries with acceptable surface finish at the required rate of production in the most economical way. The unwanted vibrations must be arrested in order to ensure higher accuracy along with productivity. Lot of research has been done in the past year to replace the cast iron material of machine tool structure with non conventional material such as composite material. In the present work the study is done on application of composite material for machine tool structure to reduce the vibration of machine tool.

***Keywords* :Milling Machine, Vibration Damping, Composite layers, Frequency, amplitude**

I. INTRODUCTION

Machining and measuring operations are invariably accompanied by relative vibrations between work piece and tool. These vibrations are due to one or more of the following causes:

(1) in homogeneities in the work piece material;
(2) Variation of chip cross section;
(3) Disturbances in the work piece or tool drives;
(4) Dynamic loads generated by acceleration/deceleration of massive moving components;
(5) Vibration transmitted from the environment;
(6) Self-excited vibration generated by the cutting process or by friction (machine-tool chatter).

The adverse and undesirable effects of these vibrations include reduction in tool life, improper surface finish, unwanted noise and excessive load on the machine tool. A machine tool is expected to have high stiffness in order to avoid such effects. Hence the machines are to be made of robust structured materials through passive damping technology to suppress the chatter vibrations and thereby increasing the production rates.

II. LITERATURE REVIEW

Dai Gill Lee et al. [1] have attempted and succeeded in improving the damping capacity of the column of a precision mirror surface grinding machine by designing a hybrid column made up ofglass fiber reinforced epoxy composite plates adhesively bonding to a cast iron column. Rahman et al. [2] attempted to review the some important developmental research in the areaof non-conventional materials for machine tool structures. Krishna Mohan Rao G,.et al [3] have done analysis of passive damping technique on conventional radial drilling machine tool bed using composite material.Vitor A. Ducatti , Rosa C. Lintz . José M. Santos et al [4] have done Comparative study with different material for manufacturing of machine tool structure. Venkata Ajay Kumar. et al [5] have done Modelling and Analysis of CNC Milling Machine Bed with Composite Material.A.Selvakumar, P.V. Mohanram et al [6] have studied the mechanical characteristics of an epoxy granite beam the conventional materials such as cast iron and steel with reference to constant stiffness.S.S. Abuthakeer,et al [7] improve the stiffness, natural frequency and damping capability of machine tool bed using a composite material containing welded steel and polymer concreteOkuba et al. [8] have succeeded in improving the dynamic rigidity of machine tool structures.It was established experimentally by Haranath et al. [9] that applied damping treatment using viscoelastic layers can effectively increase the damping of machine.Almost for 2000 materials Lazan [10] conducted comprehensive studies and experimentation to know general nature of material damping.Gibson et al.[11] and Sun et al.[12] assumed viscoelasticity to describe the behavior of material damping of compositesThe concept of specific damping capacity (SDC) was adopted in the damped vibration analysis by Adams and his co workers [13], Morison [14] . The concept of damping in terms of strain energy was apparently first introduced by Ungar et.al [15] and was later applied to finite element analysis by Johnson et.al [16]. Gibson et.al [17] has developed a technique for measuring material damping in specimens under forced flexural vibrationSINGH S. P et al. [18] analyzed damped free vibrations of composite shells using a first order shear deformation theoryChandra et al. [19] has done research on damping in fiber-reinforced composite materials which involve theory behind composite damping mechanisms such as macro mechanical ,micromechanical and Viscoelastic approaches.

III. EXPERIMENTATION

A SPECIMEN DETAILS

Table 1 Specimen Details

Sr. No	Name of the Material	Cross section (mm)
1	Glass Fiber Polyester	210x210x6
2	Glass Fiber Epoxy	210x210x5
3	Mild steel	210x210x10

Fig 1 Glass fiber epoxy , Glass fiber polyester and Mild steel

B INSTRUMENTATION

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

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

Fig 2 Digital Storage Oscilloscope of Tektronix 4000 series and Vibration pickup

C. EXPERIMENTAL PROCEDURE

The work specimen of 210mm x 210mm x10mm is a mild steel square plate. Four holes of 18mm diameter are drilled on the specimen at the corners. The glass fiber epoxy and polyester composite plates are thoroughly cleaned and polished. Plates are 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 18mm 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 glass fiber polyester plates each of 6mm 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 glass fiber epoxy plates each of 5mm 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 a cutting fluid.

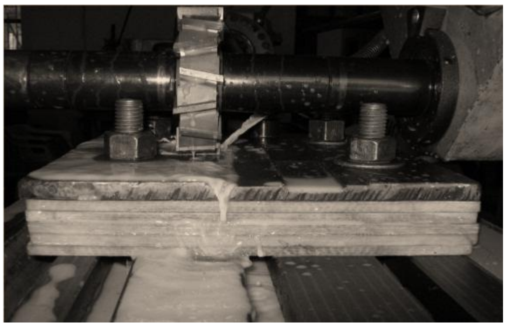

Fig Five layers of Glass fiber polyester bolted to the slotted table milling machine

IV. RESULT AND DISCUSSION

Table I gives the experimental values for glass fiber polyester plates. It is observed that when the number of layers are increased, the signal amplitude has decreased this shows presence of composite layers increased the counter vibration characteristics of the system. It is also observed that when number of layers are increased from 4 to 5 the amplitude of vibrations are increased abruptly, it represents after a certain limit it would have a negative effect with much of the progress.

Table I Experimental Frequency and Amplitude data for Glass fiber polyester

Sr. no	Number of layers	Signal Amplitude (mV)	Time Period(Its)	Frequency (KHz)	RMS Amplitude (mV)
1	5	49.6	292.0	3.425	9.99
2	4	46.4	339.0	2.786	10.2
3	3	23.2	978.7	1.022	5.10
4	2	30.4	510.0	1.961	6.75
5	1	52.4	902.5	1.108	13.4

Table II gives the experimental values for glass fiber epoxy plates. It is observed that when the number of layers are increased, the signal amplitude has decreased this shows presence of composite layers increased the counter vibration characteristics of the system. It is also observed that when number of layers are increased from 3 to 5 the amplitude of vibrations are increased abruptly, it represents after a certain limit it would have a negative effect with much of the progress.

Table II Experimental Frequency and Amplitude data for Glass fiber epox

Sr. no	Number of layers	Signal Amplitude (mV)	Time Period (Its)	Frequency (KHz)	RMS Amplitude (mV)
1	5	67.2	421.9	2.37	16.8
2	4	51.2	558.1	1.792	13.2
3	3	40.0	537.5	1.860	9.04
4	2	28.8	441.7	2.264	7.61
5	1	20.8	845.0	1.183	5.26

Table III gives the experimental values for sandwich layers of composites considered. It is observed that when the number of layers are increased, the signal amplitude has decreased this shows presence of composite layers increased the counter vibration characteristics of the system. The corresponding values for mild steel plate are given in table IV. It is also observed that when number of layers are increased from 8 to

10 the amplitude of vibrations are increased abruptly, it represents after a certain limit it would have a negative effect with much of the progress.

Table III Experimental data for the sandwich plates of Glass fiber epoxy and polyester

Sr. no	Number of layers	Signal Amplitude (mV)	Time Period (Its)	Frequency (KHz)	RMS Amplitude (mV)
1	10	39.2	740.0	1.351	9.56
2	8	49.6	716.7	1.395	11.7
3	6	33.6	692.5	1.444	8.06
4	4	59.2	502.3	1.99	13.5
5	2	65.6	437.5	2.286	14.1

Table IV Experimental data for the Mild steel plate

Sr. no	Number of layers	Signal Amplitude (mV)	Time Period (Its)	Frequency (KHz)	RMS Amplitude (mV)
1.	1	59.2	618.6	1.617	15.6

Hence optimum Number of plates is to be decided to profitably damp out the vibrations and This optimum number of plates is different for glass fiber polyester and glass fiber epoxy which is shown in table v

Table V Optimum no. of plates and Height of machine too bed

Type of composite	**Optimum no. of plates**	**Height of the machine bed**
Glass fiber polyester	Three	18 mm
Glass fiber epoxy	Two	10mm
Sandwich plates	Six	33mm

V. CONCLUSION

1. Use of composite material reduces vibration of the system as desired which is justified from the observation.
2. With the increase in number of layer of composite at an optimum level the vibration is decreased considerably.
3. Abrupt increase in vibration amplitude has also been observed with increase in number of layers of composite above an optimum limit interposed between table and work piece.
4. The results obtained are compared with respect to each other. Glass fiber epoxy material can be used for machine tool structures to reduce the undesirable effects of vibrations.

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