Paper ID: AM-01

Investigation of the Effect of Composite Bed on Milling Machine to Reduce Chatter

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Abstract

In general machine tool structure like lathe, milling machine, broaching, and grinding machine etc are subjected to regular unwanted vibration .This machine tool vibration or chatter are deleterious to machining operation . It result unwanted surface roughness of machined parts, shorter tool life and excessive noise, hence are to be necessarily damped out. This paper shows a systematic process of reducing vibration by using damping material. In this paper, Glass fiber polestar is used as damping material with varying thickness. An end milling operation is carried out and the vibration signal is recorded on the screen of digital phosphorus storage oscilloscope. The signal and the RMS amplitude, frequency and time period of vibration are recorded. The experiment is repeated for different number of piece of material. The surface roughness of the machined surfaces is checked by Surface profilometer. It is observed that the vibration amplitude, surface roughness decreases with the increases in a optimum number of layers of damping material.

Keywords: *Milling machine, vibration or chatter, surface roughness, oscilloscope, Surface profilometer*

1. Introduction

The function of the machine tool is to produce a work piece of the required geometric form with an acceptable surface finish at high rate of production in the most economic way [1].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. Machine tools structure must possess high dumping, high static and dynamic stiffness. High cutting speeds and feeds are essential requirement of a machine tool 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. This static stiffness of a machine tool can be increased by using either higher modulus material or more material in the structure of a machine tool. However, it is difficult to increase the dynamic stiffness of machine tools with these methods because the damping of machine tool structure cannot be increased by increasing the static stiffness. Sometimes high specific stiffness is more important than stiffness to increase the natural frequency of the vibration of the machine tool structure in high speed machining [2].Often the most economic way of improving a machine tool with high resonance peaks is to increase the damping rather than static stiffness even though it is not easy to increase the damping of the machine tool structure. The chatter is a nuisance to the metal cutting process and can occur on any chip producing tool. Chatter or self-excited vibrant occurs when the width of cut or cutting speed exceeds the stability limit of machine tool [3, 4].The effects of chatter are all adverse affecting surface finish, dimensional accuracy, tool life and machine life [5].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. If the damping is too small to dissipate the vibration energy of the machine tool, the resonant vibration occurs when the frequency of machining operation approaches one of the natural frequencies of the machine tool structure. Therefore the material for the machine tool structure should have static stiffness and damping in its property to improve both the static and the dynamic performance.

1.1 Review on research done in damping of composite materials

Bert [6] and Nashif al.[7] 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. Chandra et al.[8] has done research on damping in fiber reinforced composite materials.

Composite damping mechanisms and methodology applicable to damping analysis is described and had presented damping studies involving macro mechanical, micromechanical and Viscoelastic approaches. Gibson et al.[9] and Sun et al.[10,11] assumed viscoelasticity to describe the behavior of material dumping components.

The concept of specific damping capacity (SDS) was adopted in the damped vibration analysis by Adams and his co workers [12-13].Morison[14] and Kinera et al.[15].

1.2 Chatter in the milling machine

The milling operation is a cutting process using a rotating cutter with one or more teeth. An important feature is that the action of each cutting edge is intermittent and cuts less than half of the cutter revolution, producing varying but periodic chip thickness and an impact when the edge touches the work piece. The tooth is heated and stressed during the cutting part of the cycle, followed by a period when it is unstressed and allowed to cool. The consequences and thermal and mechanical fatigue of the material and vibrations, which are of two kinds: forced vibrations, caused by periodic cutting forces acting in the machine structure and chatter vibrations, which may be explained by two distinct mechanism, called “mode coupling” and “regeneration waviness”, explained in Tobias(1965),Koenigsberger & Tlusty(1967) and Budak & Altintas(1995).

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, as explained by Altintas(2000).In milling, one of the machine tool work piece system structural modes is initially excited by cutting forces. The waved surface left by a previous tooth is removed during the succeeding revolution, which also leaves a wavy surface due to structural vibrations. The cutting forces become oscillatory whose magnitude depends on the instantaneous chip dynamic thickness, which is a function of phase shift between inner and outer chip surface. The cutting forces can grow until the system becomes unstable and the chatter vibrations increase in a point when the cutter jumps out of the cut or cracks due the excessive forces involved. These vibrations produce poor surface finishing, noise and reduce the life of the cutter. In order to avoid these undesirable effects, the feed rate and the depth of the cut are chosen at conservative values, reducing the productivity.

1.3 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

(A)Oscilloscope (B)Vibration measuring probe (C) Power supply unit

1.4 Composite used in the work is Glass fiber polyester

Fiberglass is made from extremely fine fibers of glass. It is used as a reinforced agent for many polymer products; the resulting composite material, properly known as fiber-reinforced polymer (FRP) or glass-reinforced plastics (GRP), is called "fiberglass" in popular usage. Uses for regular fiberglass 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.
Polyester is a category of polymers which contain the ester functional group in their main chain. Although there are many types of polyester, the term "polyester" as a specific material most commonly refers to polyethylene. Depending on the chemical structure polyester can be a thermoplastic or thermo set; however the most common polyesters are thermoplastics. Polyesters are used to make "plastic" bottles, films, tarpaulin, canoes, liquid crystal displays, holograms filters, dielectric film for capacitor, film insulation for wire and insulating tapes.

2. Experimental Procedure

The work specimen of 70mm x 55mm x 15 mm is a mild steel square plate. The glass fiber e polyester composite plates are thoroughly cleanse 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. All the plates are carefully made homogeneously similar to avoid interfacial vibrations and slipping. The work piece is then mounted onto the layered sheets of composites and tightly clamped. Initially mild steel plate is machined with no layer under it .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. The number of layers is increased to 7 layers and the observations are recorded. The experiments are conducted for 0, 1,2,3,4,5,6,7 numbers of layers respectively. Finally mild steel plate is machined with no layer under it and the readings are noted and compared.

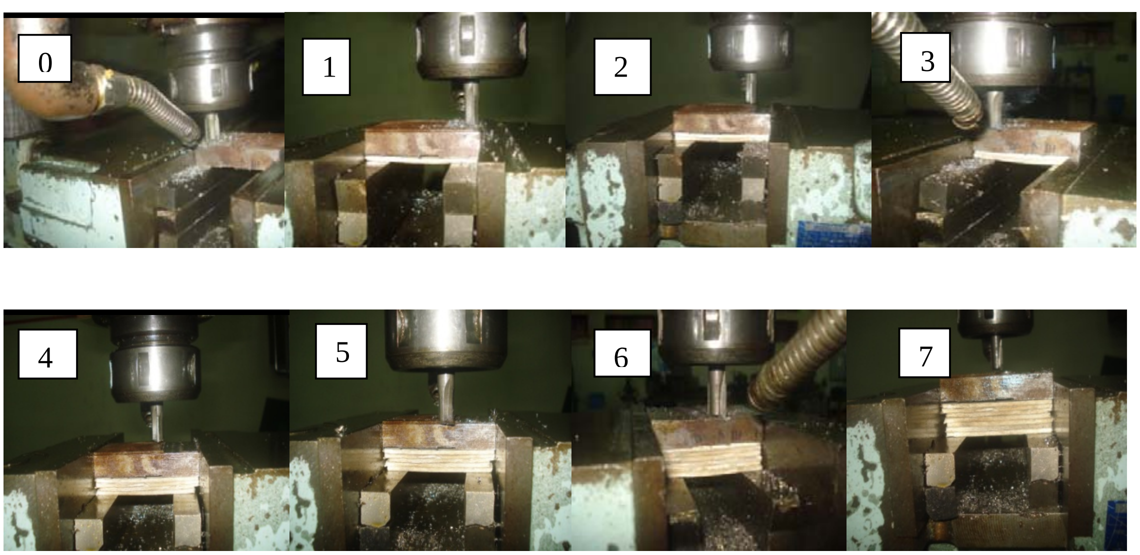

Figure 1. Experiment proceed on increasing the number of damping material

An End milling cutting operation with constant feed of 16mm/min and depth of cut if .02mm is performed during all the experiments. An oil-water emulsion made from animal fat is used as a cutting fluid.

The surface roughness of the job pieces are measured on Surface profilometer .The microscopic view of the surfaces are shown in the Figure-2. The value of Signal Amplitude(mV), Time period(10^{-6} s), Frequency(KHz), RMS amplitude (mV), Surface roughness for different cutting conditions are tabulated in the Table-1

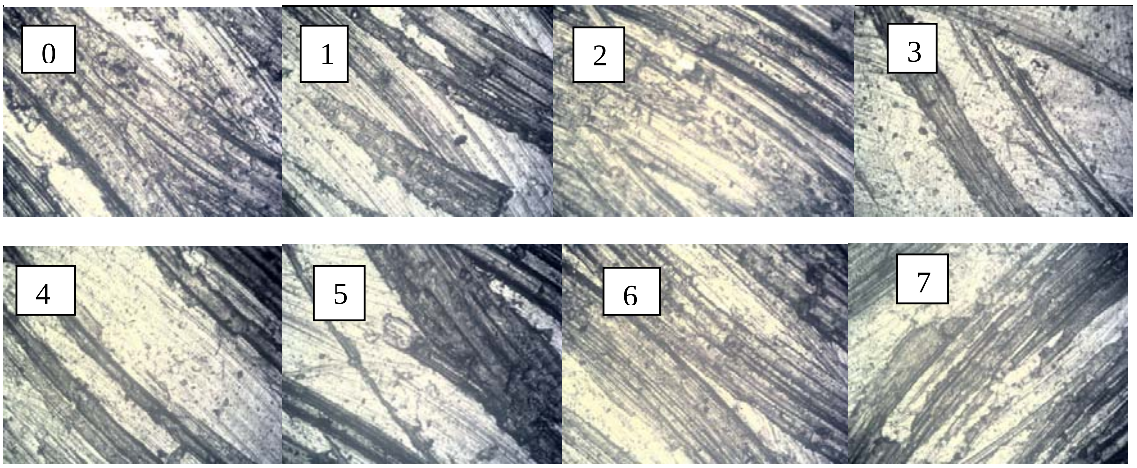

Figure-2: Microscopic view of surface produced on different condition

Table 1. Signal Amplitude(mV), Time period(10^{-6} s), Frequency(KHz), RMS amplitude (mV), Surface roughness for different cutting condition

No of plates	Signal Amplitude(mV)	Time period(10^{-6} s)	Frequency(KHz)	RMS amplitude (mV)	Surface roughness
0	65.6	437.5	2.286	14.1	0.96
1	52.1	468	2.09	11.5	0.925
2	45.8	503.8	1.87	10.2	0.88
3	39	569.4	1.65	9.4	0.83
4	**33.6**	**692.5**	**1.444**	**8.06**	**0.80**
5	36.2	745.9	1.49	8.9	0.82
6	47.2	799.2	1.55	10.3	0.87
7	53.9	827	1.72	10.7	0.91

3. Conclusion

The above result shows the variation of signal amplitude with respect to number of layers for different combinations of composites. It is observed that when the numbers of layers are increased, the signal amplitude has decreased. The maximum amplitude is obtained when no composite material was used indicating that the

presence of composite material decreases the vibration amplitude and increases counter vibration characteristics of the system. This shows that with increase in the plates the damping can be increased but only to a certain limit. Also by analyzing the surface roughness on Surface profilometer it is observed the same result.
Hence optimum level of plates is to be decided to profitably damp out the vibrations.

4. References

[1] The Machine Tool Industry Research Association, A Dynamic Performance Test for Lathes, July, 1-86, (1971).
[2] Welbourn , D.B. and Smith, J.D., "Machine Tool Dynamics, Cambridge University Press, Chap.1, Chap.5, Chap.8, (1970).
[3] Koenigsberger, F. and Tlusty, J., "Machine Tool Structure". Pergamon Press, Vol.1, Sect.2, (1970).
[4] Cook, N.H., "Manufacturing Analysis, Addison-Wesley Publishing Company, Chap.3, Chap.7. , (1986).
[5] Merritt, H.E. , "Theory of Self-Excited Machine Tool Chatter", Journal of Engineering for Industry. Transactions of ASME, 447-454 (1965).
[6] Bert, C.W., "Composite materials: A survey or the damping capacity of fiber reinforced composites in damping applications for vibration control", AMD-Vol. 38. (1980).
[7] Nashif , A.D, Jones, D.I.G and Henderson, J.P. Vibration Damping, Wiley, New York, (1985).
[8] Chandra, R., Singh S.P, and Gupta.K Damping studies in fiber-reinforced composites-a review. Composite Structs, 46(1), 41-51, (1999).
[9] Gibson, R.F., Chaturvedi, S.K. and Sun, C.T., "Complex moduli of aligned discontinuous fiber-reinforced polymer composites", J. Mater Sci., Vol. 17. pp. 3499-3509 (1982).
[10] Gibson, R.F., Chaturvedi, S.K. and Sun, C.T., "Internal damping of short- fiber reinforced polymer matrix composites", Comput. Struct 20, pp. 391-401, (1985).
[11] Sun, C.T., Wu, J.K. and Gibson, R.F., "Prediction of material damping of laminated polymer matrix composites". J. Mater. Sci. 22, pp. 1006-1012, (1987).
[12] Adams, R.D. and Bacon, D.G.C, "Effect of fiber orientation and laminate geometry on dynamic properties of CFRP , J Compos.Mater. 7, pp. 402-428, (1973).
[13] Lin D.X, Ni R.G and Adams R.D, "Prediction and measurement of the vibrational damping parameters of carbon and glass fiber-reinforced plastics plates", J. Composite. Materials. 18, pp. 132-152 (1984).
[14] Ni R.G and Adams R.D., "A rational method for obtaining the dynamic mechanical properties of lamina for predicting the stiffness and damping of laminated plates and beams", Composites 15, pp. 193-199, (1984).
[15] Morison W.D, "The prediction of material damping of laminated composites". Can. Aeronaut. Space J. 28, pp. 372-382, (1982).