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Prediction and Control of Lathe Machine Tool vibration

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ABSTRACT

Unwanted vibration in machine tools like lathe machine, drilling machine, grinding machine as it affects on the quality of machined parts, tool life during machining operation. Hence these unwanted vibrations are needed to be controlled. The prediction and control of vibration between the tool and work piece is important as guideline to the machine tools user for an optimal selection of depth of cut, cutting speed, tool feed rate to minimize the vibration. In machining operation there are different variables deleterious the desired result. In this process the behavior of machine tool, cutting tool life and cutting tool vibration are the complex phenomenon which influences on the dimensional precision of the components to be machined, the cutting tool vibrations are mainly influenced by cutting parameters like cutting speed, depth of cut and tool feed rate. In this project work, CNC lathe cutting tool vibrations are controlled the tool holder is supported with and without damping pad made of silicon rubber.

Keywords— **Cutting tool vibration,Damping pad,Analysis of variance,Data acquisition system,Influences of the cutting parameter.**

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I. INTRODUCTION

Machine and machine tool are always subjected to vibration. These vibrations are mainly causes due to in-homogeneity's in the work piece material, Variation of chip cross section, Disturbances in the work piece or tool drives, Dynamic loads generated by acceleration/deceleration of massive moving components, Self-excited vibration generated by the cutting process or by friction (machine-tool chatter). The tolerable level of relative vibration between tool and work piece, is determined by the required surface finish and machining accuracy as well as by detrimental effects of the vibration on tool life and by the noise which is frequently generated.

In cylindrical grinding and turning, when a work piece which contains a slot is machined, visible marks frequently are observed near the "leaving edge" of the slot or keyway. These are due to a "bouncing" of the grinding wheel or the cutting tool on the machined surface. They may be eliminated or minimized by closing the recess with a plug or with filler. When the transients do not significantly decay between the pulses, dangerous resonance vibrations of the frame and/or the drive can develop with the fundamental and higher harmonics of the pulse sequence. The danger of the resonance increases with higher cutting speeds. Simultaneous engagement of several cutting edges with the workpiece results in an increasing dc component of the cutting force and effective reduction of the pulse intensity, while run out of a multi-age cutter and inaccurate setup of the cutting edges enrich the spectral content of the cutting force and enhance the danger of resonance. Computational synthesis of the resulting cutting force is reasonably accurate.

Since machine tools operate in different configurations (positions of heavy parts, weights, dimensions, and positions of work pieces) and at different regimes (spindle rpm, number of cutting edges, cutting angles, etc.), different vibratory modes can be prominent depending on the circumstances. The stiffness of a structure is determined primarily by the stiffness of the most flexible component in the path of the force. To enhance the stiffness, this flexible component must be reinforced. To assess the influence of various structural components on the overall stiffness, a breakdown of deformation (or compliance) at the cutting edge must be constructed analytically or experimentally on the machine. Breakdown of deformation (compliance) in tensional systems (transmissions) can be critically influenced by transmission ratios between the components.

Increasing the flange thickness does not necessarily increase the stiffness of the connection, since this requires longer bolts, which are more flexible. There is an optimum flange thickness (bolt length), the value of which depends on the elastic deformation in the vicinity of the connection. Deformation of the bed is minimized by placing ribs under connecting bolts. The efficiency of bolted connections, and other static and dynamic structural problems, is conveniently investigated by scaled model analysis.

II.LITERATURE SURVEY

Al-Habaibeh&Gindy [1] they have found in a machining operation, vibration is frequent problem, which affects the machining performance and in particular, the surface finish and tool life. Severe vibration occurs in the machining environment due to a dynamic motion between the cutting tool and the work piece. In all the cutting operations like turning, boring and milling, vibrations are induced due to the deformation of the work piece, machine structure and cutting tool .Also new systematic approach, ASPS, to optimize condition monitoring systems is described. The system utilizes O as method to minimize the experimental work needed and to give a good evaluation of the designed monitoring system. The average dependencies of the proposed systems are compared with the pattern recognition capability of a back propagation neural networks and a fuzzy logic classifier.

Ahmed SyedAdnan and Sathyan Subbiah [2] observed reduction in cutting forces and feed forces when transverse vibrations are applied. Chip thickness is also reduced and surface finish is improved upon application of vibration. This study investigates vibrations that are applied along the cutting edge and perpendicular to the cutting velocity. Such a vibratory motion is expected to provide a small sawing action that will enhance the ductile fracture occurring ahead of the cutting tool as the chip separates from the bulk work material. This enhancement in fracture will then contribute to reducing the chip thickness and cutting forces.

Y. Altintas and M.R. Khoshdarregiet [3]integrated vibration avoidance and contouring error compensation were experimentally demonstrated to improve the damping and contouring accuracy on a two-axis table. Also machine tools exhibit residual vibrations and give contouring errors during high speed, high acceleration contour machining operations. The vibrations are caused by the structural modes of the machine tool. The source of the contouringerrors is both due to limited bandwidth of the servo drives as well as the vibration avoidance methods used in generating the trajectory commands.

S. S. Abuthakeer, P.V. Mohanram & G. Mohan Kumar [4] worked on the cutting tool vibrations and control of cutting tool vibration using a damping pad made up of neoprene. Experiments were conducted in CNC lathe, were the tool holder is supported with and without damping pad. The cutting tool vibration signals were collected through a data acquisition system supported by Lab VIEW software. To increase the buoyancy and reliability of the experiment a full factorial experimental design was used. The experimental studies and data analysis have been performed to validate the proposed validate proposed damping system. The online tests show that the proposed system reduced the vibrations of cutting tool to a greater extend. The vibration analysis was done without any damping pad under actual machining conditions.

III. OBJECTIVES OF THE PROJECT

It is observed that all researcher have focused on effect cause parameter on vibration and effect of vibration on various parameter like surface roughness, life of cutting tool, reliability of system etc .Also they provide suitable solution for that. But they very little focused on damping treatments in actual applications which based on viscoelastic materials with viscous devices being the second most actively used (the use of viscous devices is greater for isolation and shock) and method of control of the machine tool vibration.Predict and suppressing the vibration level of cutting tool in CNC lathe, by using passive damping pad of viscoelastic material.

IV. EXPERIMENTAL METHODOLOGY AND EXPERIMENTATION

It is methodology based on statistics and other discipline for arriving at an efficient and effective planning of experiments with a view to obtain valid conclusion from the analysis of experimental data. Design of experiments determines the pattern of observations to be made with a minimum of experimental efforts. To be specific Design of experiments (DOE) offers a systematic approach to study the effects of multiple variables / factors on products / process performance by providing a structural set of analysis in a design matrix.Number of Experiments to be performed is decided with the help of Taguchi Method It is assume that inherent vibration, tool wear and L/D are constant throughout experimentation and Cutting Speed, Depth of cut, nose radius & feed rate are varied at different levels.All varying parameter are varied at 3 levels as follows:

Parameters	**Level 1**	**Level 2**	**Level 3**
Nose Radius (NR)	0.4	0.8	1.2
Cutting speed (CS) C1	420	520	620
Depth of cut (DOC) C2	0.4	0.5	0.6
Feed rate(FR) C3	0.15	10.2	0.25

Table No 1. Level of Experimental Parameters

According to above input to the MINITAB 15 software for optimum no of experiments it gives the L9orthogonal array for various combinations of the different levels of the three factors.

V. EXPERIMENTAL DETAILS

The experimental setup for this project is as shown in figure. It includes a CNC lathe of turning with MIDAS-0 turning center tool holder, work piece without any cutting fluid. The tool is instrumented with two accelerometer (of Brule&Kjaer type 4517).The accelerometer signals has taken to data aquistation card system using lab view software.The vibration data is captured by DAC system. This include hardware section, circuit design & implementation hardware interface, circuit turbo shooting, filtering, computer software programming.For experiment purpose work piece of SS304 is used. Shape of work piece is solid round bar. Dimension of solid round bar is of Diameter of 30 mm and length is 30mm

Fig 1 Experiment Set up

For experiment purpose insert triangular shape is use. It is manufactured by SANDVIK Company. Specification of insert is TNMG 160408-61 having grade no. 4015.

Table No 2.Observation for silicon damper

No	NR	CS	DC	FR	Amplitude of Acceleration of cutting tool in g				Surface Roughn	
					Axial Direction (RMS)		Tangential Direction (RMS)			
					Without Damper	With Damper	Without Damper	With Damper	Without Damper	Wi Damper
	0.4	420	0.4	0.15	1.833	1.46	2.65	1.93	1.684	1.08
	0.4	520	0.5	0.2	2.8	2.1	4.7	2.93	1.67	1.01
	0.4	620	0.6	0.25	3.89	3.28	7.6	5.99	2.461	1.47
	0.8	420	0.5	0.25	2.59	1.66	6.31	3.29	2.26	1.22
	0.8	520	0.6	0.15	4.38	2.29	10.13	4.36	1.805	1.65
	0.8	520	0.4	0.2	10.29	2.55	7.36	5.36	2.401	1.77
	1.2	420	0.6	0.2	2.02	1.97	4.32	2.69	2.08	1.68
	1.2	520	0.4	0.25	3.02	2.88	8.01	3.43	2.204	0.58
	1.2	620	0.5	0.15	4.3	4.05	12.51	4.46	2.60	1.04

Table No 3. Observation for silicon damper

No	NR	CS	DC	FR	Amplitude of Acceleration of cutting tool in g				Surface Rough	
					Axial Direction (RMS)		Tangential Direction (RMS)			
					Without Damper	With Damper	Without Damper	With Damper	Without Damper	With Damper
	0.4	420	0.4	0.15	1.833	1.59	2.65	2.26	1.684	1.429
	0.4	520	0.5	0.2	2.8	2.37	4.7	3.98	1.67	1.65
	0.4	620	0.6	0.25	3.89	3.67	7.6	7.02	2.461	1.88
	0.8	420	0.5	0.25	2.59	2.1	6.31	3.62	2.26	0.9
	0.8	520	0.6	0.15	4.38	2.6	10.13	5.24	1.805	1.87
	0.8	520	0.4	0.2	10.29	4.31	7.36	6.94	2.401	1.027
	1.2	420	0.6	0.2	2.02	2.01	4.32	3.98	2.08	1.18
	1.2	520	0.4	0.25	3.02	2.62	8.01	6.98	2.204	0.969
	1.2	620	0.5	0.15	4.3	4.11	12.51	10.41	2.60	1.805

VI. RESULT AND DISCUSSION

The vibration phenomenon for various cutting condition has been analyzed using Lab VIEW software. The plan of the experiment was developed not only to assess the effect of cutting speed, feed rate and depth of the cut but also to study the effect of damping pad on the cutting tool vibration, tool temperature and surface roughness. Table illustrates the experimental result of vibration in both tangential and axial cutting direction. After analysis of the vibration, passive damping pad is provided below the cutting tool elements. Now the same experiment was carried out for various cutting condition and at various damping material, also corresponding cutting tool vibration and surface roughness are measured.

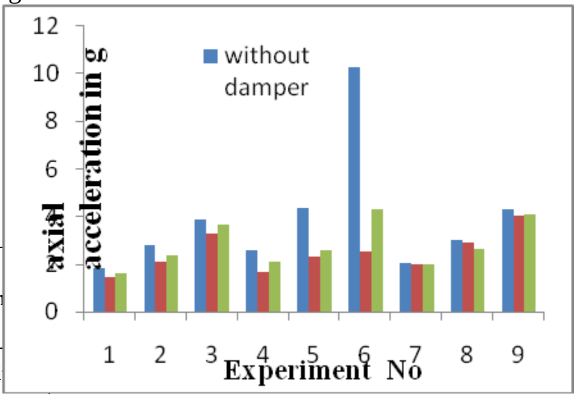

Fig2.Comparison of damper based on axial acceleration

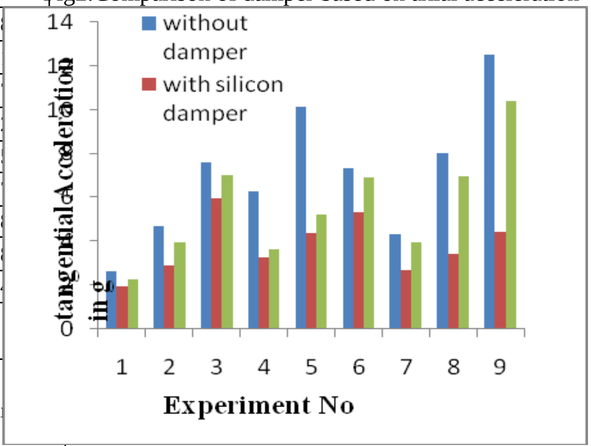

Fig 3. Comparison of damper based on Tangential acceleration

It is observed that after using passive damping, axial acceleration of machine tool is get reduced.Out of these dampers Silicon damper having maximum damping capacity than S-20 damper. Silicon damper absorbed 26.8% axial acceleration while S-20 dampers absorb only 14.9% , Silicon damper absorbed 41.75% Tangential Acceleration while S-20 dampers absorb only 15.91%

Regrassion Analysis

By using this data we can compare the vibration parameter with damp condition and without damp condition. Also ANOVA and Regression analysis can validate above result.

A. *The Regression For Axial Acceleration Without Damper*

Axial Acceleration =0.858333N R + 0.007978SS +1.105556DoC +0.033333 FR -2.91937

Regression Statistics	
Multiple R	*0.867294*
R Square	*0.8078*
Adjusted R Square	*0.707144*
Standard Error	*0.454549*
Observations	*9*

Table No 4.From above dicussion we observed that R Square is 86 % while adjusted R Square is 80 %Therefor it indicated that cutting parameters closely co-related with axial acceleration

Regression for Tangential Acceleration with Silicon damper

Tangential Acceleration =3.38 N R + 0.0241 SS +0.105 DoC -0.967 FR -9.51

SUMMARY OUTPUT

Multiple R	0.960523742
R Square	0.922605859
Adjusted R Square	0.908534197
Standard Error	0.725483178
Observations	09

Table No 6. From above dicussion we observed that R Square is 96 % while adjusted R Square is 92 %Therefor it indicated that cutting parameters closely co-related with axial acceleration.

Regression for Tangential Acceleration without damper

Tangential Acceleration =4.120833**N R** + 0.023672**SS** +6.727778**DoC** -11.2333**FR** -9.6553

SUMMARY OUTPUT

Regression Statistics	
Multiple R	0.853392
R Square	0.728279
Adjusted R Square	0.678875
Standard Error	1.665683
Observations	09

Table No. 7From above dicussion we observed that R Square is 85 % while adjusted R Square is 72 %Therefor it indicated that cutting parameters closely co-related with axial acceleration

Regression for Tangential Acceleration with S-20 damper

Tangential Acceleration =-0.09722**N R** +-0.09722**SS** +0.013211**DoC** +3.922222**FR** -6.25422

Regression Statistics	
Multiple R	0.87576
R Square	0.766956
Adjusted R Square	0.724584
Standard Error	0.707019
Observations	09

Table No 5.From above dicussion we observed that R Square is 87 % while adjusted R Square is 76 %Therefor it indicated that cutting parameters closely co-related with axial acceleration

VII.CONCLUSION

1 From Analytical Calculations, Graphs, Regression Analysis and taguchi Analysis we can conclude that, By using passive Damping machine tool vibration is suppress.Comparisons based on Axial acceleration ,tangential acceleration,and surface roughness shows Silicon damper is best than S-20. Silicon having good damping capacity which results into less vibration, less average tool temperature and good surface finish. Depth of cut is most influencing parameter for combine axial acceleration, tangential acceleration, average tool temperature and surface roughness.

2 A multiple regression model has been developed and validated with experimental results

3 Passive damping can provide substantial performance benefits in many kinds of structures and machines, often without significant weight or cost penalties. In all aspects of the studies performed, a significant reduction in tool vibration during machining was achieved for a CNC machining operations.

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