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COMPUTER AIDED ANALYSIS OF VIBRATION IN MACHINE TOOL AND DESIGN OF DAMPING SYSTEM

OmWankhede, Student, M Tech (CAD/CAM), G.H.Raisoni Academy of Engg& Tech., Nagpur
om.wankhede@raisoni.net
PrashantAwchat, Professor, G.H.Raisoni Academy of Engg& Tech., Nagpur
prashant.awchat@raisoni.net
TejpalParshiwnikar, Professor, G.H.Raisoni Academy of Engg& Tech., Nagpur
tejpal.parshiwnikar@raisoni.net

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. Therefore the present work concentrates and aims on study of different controllable parameter that affect the responses like vibration amplitude and roughness of machined part. The part to be machined is kept on sandwich of plates made up of polymer and composite material. The sandwich along with the part to be machined ate fixed on the slotted table of horizontal milling machine. The parameters that can easily be controlled are feed, RPM of cutter, depth of cut, and number of plates that form thesecondary bed material. Common up-milling operation was carried out in controlled manner. Vibration signalswere recorded on the screen of phosphorous storage oscilloscope and surface roughness of machined plate was found from the Talysurf. Finite element analysis (FEA) was carried out to know the resonance frequencies at which the structure should not be excited. In the course of the FEA some important facts have come up that lead to set some of the steps of precautions during the experimentation. Response surface methodology (RSM) is used to develop the model equation for each set of plate material.*

I. Introduction:

The performance of the large machine tools can be judged from the quality and accuracy of machining done using the machine tool. The accuracy of the machining process largely depends upon the precision of relative movement of the cutting tool and the job. The machine tools often are assemblage of several subsystems such as drive motor, gearboxes; tool holders, jobholders etc. and these assemblies are required to have highest accuracy to obtain the desired accuracy and precision of machining. The components of the machine tools or subassemblies as mentioned above are subjected to wear/tear, life expiry processes and then with passage of time the machine tools become increasingly inaccurate and thus profitability of the machining processes greatly decreases. Often people based upon judgment of the quality of workmanship obtained through the use of the machine tool, adopt repair/replace maintenance strategies.The degradation in the performance of the machine tool can be judged by resorting to scientific vibration analysis of the machine tool. The advantage with this is that it is possible to know the rate at which the degradation is occurring and thus the machine tool maintenance based upon the condition of the machine tool can be done.It is needless to say maintenance strategies are far more economical than repair/replacement based maintenance and the downtime of the machine tool can be minimized. Also condition-based maintenance enhances the life of the machine tool. We describe how vibration condition monitoring can be greatly advantageous from the point of view mentioned above.

II. Vibration Problem in Machining Process

Machining of any kind is accompanied by vibrations of work-piece and tool. These vibrationsoccur due to the following reasons.

- In-homogeneities 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
- Vibration transmitted from the environment
- Self-excited vibration generated by the cutting (machine-tool chatter).

Due to these vibrations the following phenomenon occurs.

- Reduction in tool life
- Improper surface quality
- Undesirable Noise
- Excessive load on machine tool

This phenomenon can be reduced when machine tools have high stiffness [2]. High stiffnessin machine tools can be achieved by making them by robust structured materials throughpassive damping technology.

Vibration Overview

Dynamic responses of a structure can be determined by three essential parameters

- Mass
- Stiffness
- Damping

Vibration in Machine Tools

The Machine, cutting tool, and workpiece together form a structural system which hascomplicated dynamic characteristics. Vibrations of the structural system, vibrations may bedivided into three basic types [1].

A. Free or Transient vibrations:

Impulses transferred through machine foundation to the structure, from fast traversalsof reciprocating masses like machine tables, or impulses transferred by the initial engagementof cutting tools cause free vibration. The structure is deflected and oscillates naturally untilthe damping present in the structure causes the motion to diminish to zero.

B. Forced vibration:

Forced vibration is said to be occurred by a periodic forces applied to system, likeunbalanced rotating masses or the irregular engagement of multi-tooth cutters (in this casemilling), or vibration transmitted from nearby machinery through the foundations. Themachine tool oscillating at the forcing frequency, and if this frequency matches with to one ofthe natural frequency or resonant frequency of the structure, the machine will resonate in thecorresponding natural mode of vibration.

C. Self-excited vibrations:

Dynamic Instability of the cutting process cause Self-excited vibrations. Thisphenomenon is commonly called machine tool chatter. if large tool-work engagements aregiven, oscillations build up in the structure. In this case structure oscillates in one of itsnatural modes of vibration.

Damping in Machine Tools

Damping in machine tools basically is derived from two sources one is material damping and other is slip damping. The extent of material damping is very small in comparison to the total damping in machine tools. A typical damping ratio value for material damping in machine tools is in the order of 0.003 which accounts for about 10% of the total damping. The interfacial slip damping outcomes from the contact surfaces at bolted joints and sliding joints which contribute approximately 90% of the total damping. Welded joints usually provide very small damping which may be neglected when considering damping in joints. Whereas sliding joints contribute most of the damping.

III. Literature Review

A Brief Review of the Work Done On the Machine Tool Structures

Lee et al. [5] 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 of glass fiber reinforced epoxy composite plates adhesively bonding to a cast iron column. They have calculated the damping capacity of the newly designed column for optimizing its damping capacity. They have verified that the fiber orientation and thickness of the composite laminate plate plays important affects the damping capacity. After experiments they have found out that the damping capacity of the hybrid column was 1.35 times than the cast iron column.

For machine tools having massive slides generally do not permit rapid acceleration and deceleration during the frequent starts/stops encountered in machining. Kegg et al. [6] have used composites for the huge slides for CNC milling machine. They have constructed the vertical and horizontal slides by bonding high modulus carbon-fiber epoxy composite sandwiches to welded steel structures using adhesives for a large CNC machine. These composites structures reduced the weight of slides by 34% and 26%, respectively and increased damping by 50% to 570% without decreasing the stiffness.

Rahman et al. [7] attempted to review the some important developmental research in the area of non-conventional materials for machine tool structures. They have compared many beneficial properties of some materials for machine tool structure with the cast iron. The work suggested alternative to cast iron as material for machine tool structure so that high surface finish can be achieved with high cost effective production rate. As per the results of
their studies they composite materials may be a better choice to replace conventional materials of machine tool structure.

Okuba et al. [8] have succeeded in improving the dynamic rigidity of machine tool structures. This was achieved by employing modal analysis. This technique was successfully applied machines e.g. machining cell, an arm of automatic assembling machine and a conventional cylindrical grinder. By this they have successfully reduced chatter and achieved improved surface finish of a

vertical milling machine, an NC lathe and a surface grinder.
Joint damping was increased by using epoxy resin as a bonding material between structural components of a milling machine by Chowdhury [9]. It was shown that the bonded overarm of milling machine perform better than welded and the cast iron.

Literature review in Indian context

S. No.	Name of Author	Topic	Publication Details	Findings
1	Milind A. Siddhpura, Arti M. Siddhpura, Dr. S.K. Bhave	Vibration as a parameter for monitoring the health of Precision machine tools	International Conference on Frontiers in Design and Manufacturing Engineering (ICDM-08), Coimbatore, India, February 01-02, 2008	The degradation in performance of machine tool can be judged by scientific vibration analysis of machine tool. Appropriately elected condition monitoring system can detect presence of perturbation forces, which cause damages to machine parts. Using Accelerometer as a basic transducer for condition monitoring and probes for shaft vibration, vibration behavior of machine tool can be known. Then using vibration spectrum analysis, known malfunction can be found, which gives early warning of deterioration in machine tool and will avoid breakdowns. At this time suitable repair/maintenance will maintain the quality of machining as well as good health of precision machine tool.
2	AVS. Ganeshraja1, T. Dheenathayalan,	Analysis And Control Of Vibration In Grinding Machines	IJRET: International Journal of Research in Engineering and Technology eISSN: 2319-1163, pISSN: 2321-7308.	The study reveals that the vibration was measured in grinding machine. This was the one of the major hazards in grinding machines. This study tells that vibration was analysed by the digital vibrometer and controlled by damping method. By implementing above methodologies, we can prevent the loss of accuracy and loss of production. Maintenance also the key factor for these hazards Vibration can be reduced by the periodic maintenance of the machines .If maintenance is done properly, vibration can be detected at initial stage.
3	Philip R. Dahl	Solid Friction Damping of Mechanical Vibrations	Vol 14, No. 12, December 1976, AIAA Journal, 1675.	

IV. Methodology

- Selection of machining parameters for analysis of vibration
- Analysis of vibration responsible for tool damage
- Computer aided analysis of vibrations in machine
- Study of various damping system
- Selection and design of damping system.

Future Scope

1. In order to understand the logic behind the choice of the monitoring system, it is necessary to deal with a few fundamentals of vibration analysis. The perturbation forces which, cause the vibrations in machine tools, could be mechanical or electrical in nature or the combination of both of them.
2. These pulsating forces cause pulsating stresses that over a certain period of operation may cause fatigue failures of the components. The failures are greatly accelerated if the frequency(ies) of the perturbation force(es) match or are in the close proximity of the natural frequency(ies).
3. This is because of resonance/near resonance induced high-level stresses. Thus depending upon the level of stresses and the duration of the operation, the failure may be because of high cycle fatigue or low cycle fatigue. As we shall discuss in the later section, it is possible to know the perturbation forces acting on the machine tool by scientifically monitoring the vibration behavior of the machine tool.

4. Thus a dedicated vibration system is not necessarily meant only for identifying and correcting the vibration problem (which, of course the system can do) on the machine tool but also for generating the information regarding the rate of deterioration of the machine tool.
5. Identify the sources and pattern of the forces that develop in machine tools during machining.
6. State the effects of the forces in machine tools and its operations.
7. Comprehend the purposes of analysis of forces acting in machine tools.
8. Visualise and evaluate the forces originated and distributed in machine tool.

Conclusion

At present study of various vibrations and damping system is done successfully done and review on various literatures previously done in same area is also completed successfully.

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