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Vibration Analysis of Lathe Machine

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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. Therefore the present work concentrates and aims on study of different controllable parameter that affect the responses like vibration amplitude.

The prediction 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 and spindle rotation to minimize the vibration. This can be done by different approaches. In this work, an experimental method is applied in which the time varying dynamic turning forces are expanded in Fourier series. The forces in contact zone between tool and work piece during the cut are evaluated by an algorithm using FFT analyzer and a dynamometer located between the work piece material and cutter geometry. The modal parameters of the machine, work piece and tool system like natural frequencies, velocity and acceleration must be identified experimentally. By using FFT analyzer it is possible to plot the frequencies, velocity and acceleration to the dynamic system. These curves relate the spindle speed with depth of cut, separating stable and unstable zone, allowing the selection of cutting parameters resulting maximum productivity and minimize the vibration.

KEYWORDS: Dynamics system, frequencies, FFT analyzer, speed, feed, depth of cut, vibration.

1. INTRODUCTION

Machining is the most important of the manufacturing processes, including machining tools.

The challenge of modern machining industries is mainly focused on the achievement of high quality, in terms of work piece dimensional accuracy, lower surface roughness, high production rate, less tool wear on the cutting tools, economy of machining in terms of cost saving and increase the performance of the product with reduced environmental impact. The turning is the one of the most prime process for metal cutting processes. In the modern industries by use of turning process there are lots off part of automobile, manufacturing machine and aerospace are produce. There for turning is the one of the most effective process for cost reduction of manufacturing component. Optimum condition of turning process is one of the important requirements.

Vibration analysis of lathe machine is used to minimize the vibration and optimize the parameters. When Lathe machines are operated at high speed they generate vibrations and noise. The principal forces, which drive these vibrations, are time varying nonlinear contact forces, which exist between the various components of the bearings:

2. PAST RESEARCH IN ROTOR-ROLLER BEARING WITH BEARING DEFECTS.

This section will provide an overview of researches on the Vibration analysis of different machine.

2.1 Chatter vibration

S.k. choudhury, n. goudimenko and V.A. kudinov[2](1996) have developed a system for on-line vibration control on a turning lathe. Established correlation between cutting parameters (speed, feed) Control of vibration during machining.

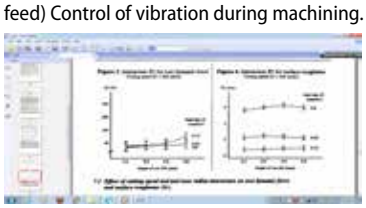

Figure 2.1

The fig. 2.1 shows the variation of depth of cut with force and surface roughness.

S. Ema, E. Marui[4](2003) Have done Theoretical analysis on chatter vibration in drilling and its suppression The stability chart of chatter vibration occurring in drills for deep hole machining was investigated theoretically. After doing the experiment they found that if the logarithmic decrement of the drills becomes greater than the λ_{2ect} by the application of an impact damper, the chatter vibration can be suppressed completely.

Guillem Quintana, Joaquim Ciurana[6] (2011) Studied on the chatter vibration problem and classify the existing methods developed to ensure stable cutting into those that use the, out-of-process or in-process, and those that, passively or actively, modify the system behavior. The principal research

a) Out-of-process strategies are focused on predicting, estimating or identifying the SLD through machining process model-ling and analytical-experimental methods.
b) In-process strategies are focused on identifying or recognising chatter through the use of several sensor technologies, pro-cess monitoring and signal treatment.
c) Passive strategies are focused on the use of passive elements, devices, methodologies or techniques that change or modify the system behavior and improve its performance against chatter.
d) Active strategies are focused on the use of elements, strategies, devices or actuators that actively modify the system behavior to suppress chatter as soon as it occurs.

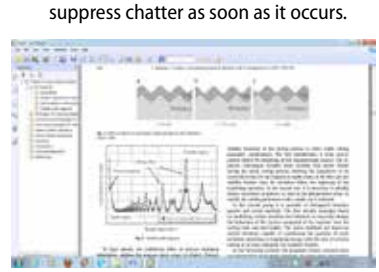

Figure2.2

2.2 Surface roughness

Thomas M., Beauchamp Y., Youssef A.Y., Masounave[1] (1996) Have find out the effect of tool vibrations on surface roughness during lathe dry turning process. Used the full factorial design and work piece material is carbon steel ANSI 1078 ,tool material is cemented carbide he found that the feed rate (f) and the tool nose radius (r) are the variables that produces the most important effects on surface roughness, followed by the cutting speed (S). Tool vibration analysis has revealed that two types of data are correlated to the cutting parameters: the amplitude of vibration measured at the tool's natural frequency and the variation of this natural frequency. These data reflect the effect of the chip variation that acts as a dynamic force which excites tool vibration. The cutting speed, although highly significant as a main effect, only affects surface roughness at specific feed rate (0.35 mm/ rev), tool nose radius (1.59 ram) and depth of cut (lower than 0.6 mm). Increase of depth of cut can help to reduce the surface roughness deterioration.

H. Wang, S. To, C.Y. Chan, C.F. Cheung, W.B.Lee[9](2009) have proposed a theoretical and experimental investigation of the influence of tool-tip vibration on surface generation in single point diamond turning (SPDT). Work material is Al6061 and parameters speed (.073m/s to 1m/s). In the present study, two characteristic peaks (twin peaks) are identified and found to be corresponding to the tool-tip vibrations by power spectrum density (PSD) analyses. A geometric model of surface roughness is proposed to take account of tool-tip vibration and it is verified through a series of experiments. The simulation results have been found to agree well with the experimental results.

2.3 Tool monitoring

D.E. Dimla Sr.[7](2004) has done an experimental investigation aimed at identifying and isolating effects of cutting conditions on cutting forces and vibrations from those arising as a result of cutting tool wear. Work material is EN8 BS 970 and tooling material Sandvik coromant SIP P10 236. Sped (100-300m/s) Machining test cuts were conducted using sharp and worn inserts and the effects of cutting conditions (depth of cut, cutting speed and feed rate) studied. Signals were recorded with significant variation of the cutting conditions when the tool was relatively fresh/sharp and/or old/worn such that only the effects of cutting conditions alteration were pronounced on the signals. Time and frequency domain was used to pinpoint the exact nature of changes on the signals due to alteration of the cutting conditions. The depth of cut and feed rate where deemed to affect the signal characteristics significantly and a specific frequency band most sensitive to the changes identified.

M. Rogante[10](2009) have done tool condition monitoring (TCM) of dry turning processes on automatic lathes, and describe the information generated by different measuring systems applied to the single point turning situation. Work material was AISI 1045 normalised medium carbon steel.The outputs measured were correlated with the state and wear rate of the cutting tools. Semi-finishing and rough-shaping tests have been carried out at different cutting speeds. Uncoated sin-tered carbide inserts have been used in both processes, while TiC –TiN coated inserts have only been used in the semi-finishing processes. The behaviours of the utilised power, the tool-holder shank vibrations and the surface roughness vs. pass number were studied. Taylor's equation was determined for the three types of inserts used. The parameters investigated show that the results are directly influenced by degree of the tool wear and also give indications when the tool insert has reached the end of its life. Coated inserts permit approximately 50% longer machining time, a higher wear mark width and reduced applied power consumption, compared with uncoated inserts. The end of tool life in the semi-finishing processes, when compared to the rough-shaping processes, refers to the higher power range used in the latter. The established relationships can be used in the evaluation of a tool insert's life and subsequently give rise to clear indications of the opportunity for higher productivity.

2.4 Dynamic analysis

Adam A. Card, Hiram A. Firpi, Matthew T. Bement, Steven Y. Liang [8](2008)
have done Work piece dynamic analysis and prediction during chatter of turning process. Lathe type used –Harding conquest T42 high precision horizontal lathe and LK-G37 laser sensor used. They investigated turning relatively compliant work pieces, so in turning operations, a common problem that can drastically degrade the quality of a machined part is regenerative chatter. Therefore it is the body that undergoes the bulk of the motion during chatter. Since it is highly impractical to instrument the work piece, a Neural Network trained with Particle Swarm Optimization is used to transform a radial displacement measurement made at the cutting tool to an estimation of the radial displacement of the work piece. This could serve as an observer in a real time control system that could mitigate chatter by appropriately actuating an active tool holder such as a fast tool servo. The work piece displacement was predicted with an average RMSE of 1.41 and 1.70mm for the two testing datasets. This current approach differs from other chatter detection investigations because with the direct displacement measurement of the tool holder and the output from the Neural Network observer, there is information about both bodies' motion

Hungsun Son, Hae-Jin Choi, Hyung Wook Park[5](2010)
A new concept of a multi-DOF reconfigurable machine (MRM) has been developed. They focused on the design concept of a three DOF desktop reconfigurable machine, as well as analyses of both the static and dynamic structural characteristics, which indicate the effect of vibration on the system for static and dynamic motions. The results successfully demonstrate that the position and orientation of the machine tool could be controlled simultaneously during machining operations. Dynamic simulations and experimental results using position feedback control were presented to illustrate the performance and features of the system. The MRM system developed here can be used to reconfigure the orientation of a spindle unit on demand. In addition, it is lightweight, has a fast dynamic response and simple design, and it is inexpensive and compact but makes use of a relatively large workspace without motion singularities.

2.5 Parametric optimisation

M. Thomas, Y. Beauchamp[3](2003)
have done the experiment to find out the cutting force and tool vibration in dry turning operation. Work material used Mild carbon steel and method sued full factorial design. The tool was instrumented with strain gages (120Ω) installed in a half-bridge to compensate for the temperature effect. Two tool-bending force directions were measured along the tangential and radial axes. The tool was instrumented with a triaxial accelerometer to measure accelerations in the feed, cutting or tangential (to the rotating work piece) directions, and in the thrust or radial directions. Acceleration amplitude (m/s2) was recorded with an F.F.T. analyzer, by averaging in the frequency domain, the vibration signal during the machining process in the 0–4000 Hz frequency range, with a frequency resolution of 10 Hz. The estimation of tool modal parameters during machining is based on an assumption. Due to the cutting process, the excitation resembles a comb function that is characteristic of a periodic shock with a period T, during operation in the time domain. The FFT of a comb function is also a comb function that gives repetitive frequencies f in the frequency domain. The response spectrum is the product of the excitation spectrum (composed of the repetitive frequencies f) and of the transfer function of the mechanical system (composed of the tool's natural frequency fn). The resulting response spectrum is composed of a lot of repetitive frequencies f in the low-frequency range, and of a frequency close to the initial natural frequency fn of the tool in the high-frequency range.

3. CURRENT RESEARCH TRENDS IN VIBRATION ANALYSIS OF MACHINES.

Vibration analysis is most frequently used for machining processes as a Predictive Maintenance technique. Now a day following techniques are used for vibration analysis of machines.

1) multiple time-varying parameter (MTVP)
2) single time-varying parameter (STVP)
3) Out-of-process strategies
4) In-of-process strategies
5) On-line vibration control technology
6) Passive strategies
7) Active strategies

4. FUTURE DIRECTION OF RESEARCH

Vibration is occurring in different machines. There is scope to work with different work piece and tool materials.

Predict the dynamic forces and vibration of different machine system with consideration of roughness, thickness of lubrication film, waviness, internal clearance and the localized defect of machine.

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