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The Study of Vibration Characteristics in Head Stock of a lathe Machine at Different Cutting Conditions

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Abstract

This paper presents a study of vibration characteristics in headstock of a lathe machine, at different cutting parameters. These parameters are the cutting speed; the depth of cut and the feed rate .The transducer were used on the headstock in two directions, the vertical and horizontal (feed) direction. Also for a time domain of (10sec) in both directions. The results show that the effect of the vertical vibrations is more significant than the horizontal (feed) direction, for all of the cases investigated in this paper. Unlike the vertical vibration, the horizontal vibration is lower and steadier, when the cutting speed, the depth of cut and the feed rate are increased, Whereas the vertical vibration shows a great fluctuation when these parameters are increased.

Keywords: Vibration characteristics, cutting parameters, head stock.

Introduction

In the turning operation, chatter or vibration affects the result of the machining, as a poor surface finish and dimension inaccuracy of the machined part .The tool life is also influenced by vibrations, as it is influenced by the torque and the cutting forces. Severe noise, during the real time of cutting, frequently occurs between the cutting tool and the rotating work-piece. In all cutting operations vibrations are induced, due to the deformation of the work piece. [1].

The dimensions and the shape of the machined part may also influence the tool vibration, which is translated to the results of machining. The Machining variables, which modify the cutting performance, are:

1-The cutting speed (m/min), to satisfy machining objectives, like the productivity and tooling costs.

2- The depth of cut (mm), the depth of cut could be deep as possible, according to the cutting operations and the conditions of cut.

3-Feed rate (mm/rev), as maximum as possible.

4- Use of round-nose tools, for achieving a better surface finish.

5-The tools geometry particularly the rake angle and shear angle.

6-Also, The cutting performance is influenced by the type of cutting, orthogonal cutting or oblique cutting.

7-The use of round nose tools or grooved cutting edge tools.

The problems of metal cutting process have been widely studied, but the aim of the optimal cutting conditions has yet to be researched. On the other hand, the ratio between the force and vibration amplitudes to yield a wear index and the influence of the cutting conditions on the measured vibration signal for detecting the tool wear, are also investigated [2]. Sanjanwala et al. [3] developed a pneumatic sensor for on-line measurement for the dimensional deviation of the work piece and other researchers [4] used an

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ultrasonic sensor for the same purpose.

The cutting operation is always affected by vibrations, due to the variable speed of the tool relative to the work piece, influence of the cutting action and amount of tool wear and the variable depth of cut due to the movement of the tool [5]

Feliciano [6] presents a new machining method that efficiently cuts overhanging curve grooves on wall surfaces without causing a collision between the tool and the work piece. It also describes the development of software for 6-axis control grooving and the effect of applied ultrasonic vibrations (USV) in cutting overhanging grooves (OHG). From the experimental results, it was found that the new machining method, which is 6-axis control cutting using a non-rotational tool with the application of USV, is capable of cutting an OHG on wall surfaces correctly.

Chunxiang [7]The cutting speeds of the tool, the rake angle and clearance angle through the cycles of elliptical vibration cutting for separating type ultrasonic elliptical vibration cutting are defined initially in the present paper. Subsequently, a theoretical model of the thrust cutting force in ultrasonic elliptical vibration cutting is proposed, Inspergera [8]Analytical and experimental identifications of the chatter frequencies in milling processes are presented. In the case of milling, there are several frequency sets arising from the vibration signals, as opposed to the single well-defined chatter frequency of the unstable turning process. Frequency diagrams are constructed analytically and attached to the stability charts of mechanical models of high-speed milling.

The objective of the present work is to study the vibration characteristics at the headstock of the lathe machine during the turning operation. A transducer was used for sensing the vertical and the horizontal (feeding) vibrations induced in the headstock support and their change for various cutting conditions.

Experimental Setup

The experimental approach was carried out in two major stages. In the first stage, the experiments were performed on the vertical and horizontal (feeding) vibrations. Figure (1) shows the experimental setup, which is used in this study. The cutting tests were performed on a lathe machine, type (Takisawa/ TSL-Deluxe). The work-piece was a low carbon steel shaft (285cm) length and (18.5mm) diameter and a high-speed steel cutting tool are used for all of the experiments. The transducer was attached to the top in vertical direction on head stock and horizontal (feeding) side of head stock were support by magnetic. For the measurement of the vibrations in both vertical and horizontal directions are as shown in fig. (1). the displacement and the velocity, in the two directions, were measured with a vibrometer, type (HBM) and converted to the amplitude by applying the general relationship at the maximum case.

In this study, three cutting parameters were taken into consideration, the feed rate (mm^3/rev.), the depth of cut (mm) and the cutting speed (m/min.), or the spindle speed. And sharp cutting tools with the rake equal to 5^o and shear angle 26.7^o .All experiments were under dry cutting conditions, or no coolants or lubricants are used.

In the first experiment, the spindle speed is varied, while the feed rate and the depth of cut are kept as (0.38mm/rev, 0.1mm) respectively. In the second experiment, the depth of cut is varied, while the feed rate and the spindle speed are kept as (0.38mm/rev, 270 rpm) respectively. In

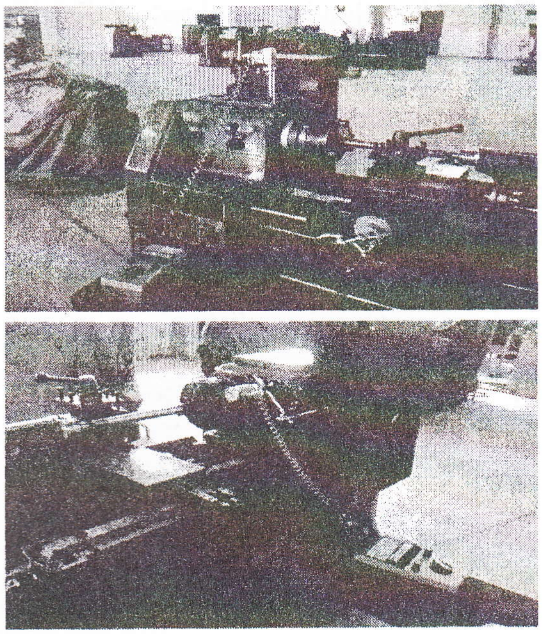


Fig (1) Experimental Setup

the third experiment, the feed rate is varied, while the spindle speed and the depth of cut are kept as (270 rpm, 0.1mm) respectively.

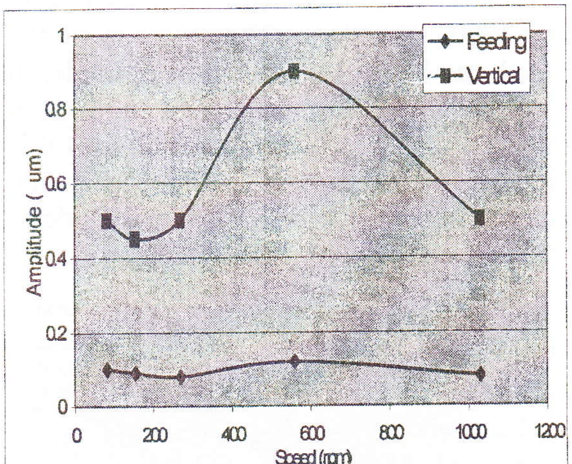
The second stage of our experiments is concerned with the time response of the vertical and feeding vibrations. For measuring the frequency, for the first ten second operating and the lathe was arranged at a spindle speed of (270 rpm, a feed rate of (0.38 mm/rev) and a depth of cut of (0.1mm). The dimension of the work-piece is taken the same, as for the first stage tests. In the forth experiment, the frequency and time response, for both the vertical and the horizontal directions are taken in to consideration.

Results and Discussion

The aim of this paper is to study the relationship between the cutting conditions and the vibration characteristics of the headstock.

From the above experimental approach of this work, the following figures can be

Figure (2) show the vibration amplitude at deferent speeds and in two directions. In the horizontal (feeding) direction, the amplitude of the vibrations in the headstock is more steady and lower than that of the vertical direction. Or, the amplitude of the vibrations, in the horizontal (feeding) direction, is not affected with increase in spindle speed (cutting speed) and it becomes nearly fixed for all the speeds. At changing the direction of feeding expected to obtain some value. Unlike the horizontal direction, the vibration amplitude, in the vertical direction, is more fluctuated and higher than that of the feeding direction. It increases with the increase in the spindle speed, to have a maximum value at about 600 rpm, and then the vibration amplitude is decreased to its initial value, at about a spindle of (1000 rpm.)

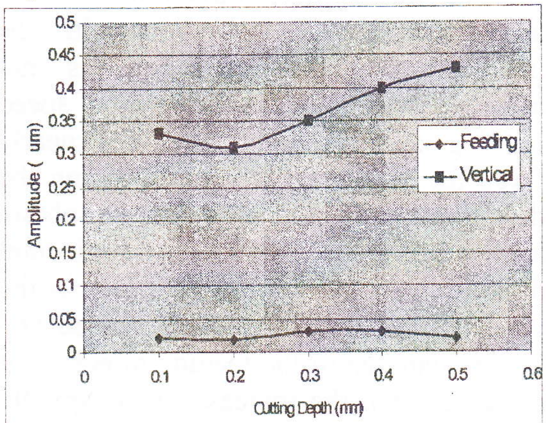


Fig(2) Amplitude versus speed at Feed rate(0.38mm/min) and cutting Depth (0.1mm) in two directions

Figure (3) shows the variation of the vibration amplitude when the depth of cut is increased from 0.1 to 0.5mm. Here also, the amplitude of the vibration in the

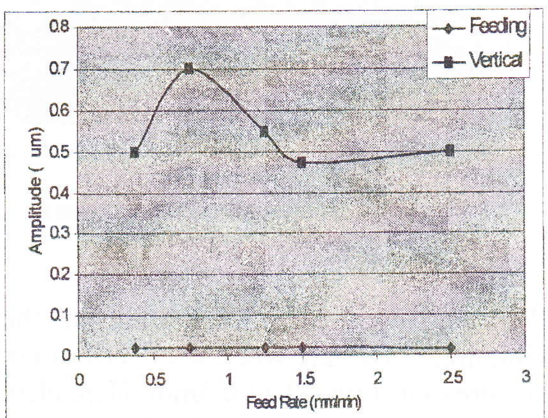
Figure (3) shows the variation of the vibration amplitude when the depth of cut is increased from 0.1 to 0.5mm. Here also, the amplitude of the vibration in the

vertical direction is higher than that of the feeding direction. In the feeding direction, the increase in depth of cut does not affect the vibration amplitude, while in the vertical direction the situation is not the same; it increases with the increase in the depth of cut.



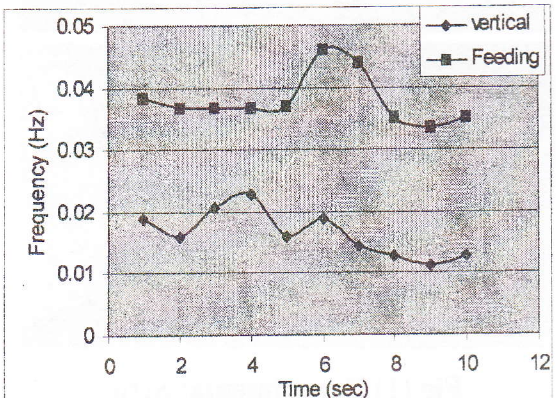
Fig(3) Amplitude versus Cutting Depth at speed(270rpm) and Feed rate (0.38mm/min) in two directions

Figure (4) shows the variation of the vibration amplitude with the feed rate in the both directions. The increase of the feed rate leads the vibration amplitude, in vertical direction, having a maximum value at about (0.075m/rev), and then it is gradually decreased. In the horizontal direction, also the vibration amplitude is very low and very steady.



Fig(4) Amplitude versus Feed Rate at speed (270rpm) and cutting depth (0.1mm) in two directions

In figure (5), the relation-ship between the time response and the frequency is studied. In contradiction to the results obtained for vibration amplitude in figures (2, 3, 4), the frequency level of the feeding vibrations are higher than of the vertical direction. However, in the both directions, the resonance occurs and the frequency level is more fluctuated for the first 5 or 6 seconds and then decreased.



Fig(5)Frequency and time response on the head stock in two directions

Now, in the basic discussions of the results obtained from this research, it could be seen that the vibrations do not occur in the cutting depth and feed rate direction, but in the cutting speed direction (vertical direction). For the effect of the cutting speed itself, it increases the vibration amplitude to have a maximum value at a spindle speed of (600 rpm)

$$V_C = \frac{\pi\, dn}{1000} \qquad (m\ /\ \min)$$

Which corresponds to a cutting speed of (35m/min), for shaft diameter used in this study, and then it is decreased, as in figure (2). This means that the higher cutting speed leads to lower vibration amplitude, as it leads to a better surface finish, which is well known in the researches of the metal cutting operations [6]. In reality, the increase of the cutting speed decreases the major problems of cutting operations, with preventing the occurrence of the built up edge, and decreasing the vertical vibrations. As a result, the surface quality is improved, which is the main factor for the tool life criterion in turning operations [9]. For the comparison between the vertical and feeding direction, it is needed to dump or to minimize the vibrations, in the vertical direction rather than feeding direction. The possibility of increasing speed acts in the positive direction for both the surface finish and the vibration decreasing. Fortunately, the increase of the cutting speed increases the productivity of the manufacturing processes.

In the feeding direction, the increase in the feed rate and the depth of cut leads to a higher metal removal rate and greater chip cross section area, as well as an increase in the cutting forces on the rake face of the tool. In fact, the feed rate and the depth of cut do not have a considerable effect in the feeding direction, but when they are increased, as in figures (1 & 2); their influence is combined with, or translated to the vertical direction vibrations. So, in a more sophisticated application, it is needed to study the vibration characteristics of the machine tools and normalizing the cutting forces generated by the feed and the depth of cut. This will be for the possibility of increasing the cutting speeds, to obtain lower vibration amplitude and a higher surface finish, for each cutting operation.

For the contradiction between the results obtained for the vibration amplitude in figures (2, 3 4) and the vibration frequency in figure (5), in the first ten seconds, the feed and the depth of cut act effectively to initiate the cutting Operation on the work-piece. So, the feeding vibration becomes higher than the vertical direction and when the initiation stage is exceeded, the cutting speed acts effectively in increasing the vibrations in vertical direction.

Conclusion

1-In the headstock of the lathe machine, the amplitude of the vibrations in the vertical direction is more important, more turbulent and higher than that of the feeding direction.

2-The vibration amplitude in the feeding direction is not significantly affected with the increase of cutting speed, the depth of cut and the feed rate, as the vibration amplitude in the vertical direction

3-For the conditions of our experiments, the amplitude of the vertical vibrations, which is more effective, begins to increase when the cutting speed exceeds the limit of (600 rpm), which corresponds to a cutting speed of (35m/min).

4-Unlike the vibration amplitude, the frequency level, in vertical direction, is lower than that of the feeding direction. In the both directions, due to the initiation stage of cut, the frequency level seems to be more fluctuated, for the first five or six second.

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لێکۆڵینەوەی ئاکارەکانی لەرینەوە لە کەللەی سووڕاوی تۆرنەدا، لە بار و دۆخی بڕینی جیاوازدا

سەڤین یاسین قەساب شێرکو عبدالکریم بابان
کولیجی ئەندازیاری/بەشی ئەندازیاری میکانیك/ زانکۆی سەلاحەدین/هەولێر/ هەرێمی کوردستان-عێراق

پوختە

لەم توێژینەویەدا، لە ئاکارەکانی لە رینە وە دەکۆڵێتەوە، لە کەللەی سووڕاوی مە کینە ی تۆرنەدا، لە بارو دۆخی جیاوازدا. ئەو گۆرانکاریانی بەکار هێنراون بریتین لە خێرایی بڕین، قوڵایی بڕین، تێکرای دەرخوارد. ئامێرە هەستەوەرەکان لە سەر کەللەی سووڕاوی تۆرنە کە دابەسترابوون، بۆ ئەوەی لەرینەوە تۆمار بکەن بە هەردوو ئاراستە ی ستوونی و ئاسۆیی، بۆ ماوە ی (١٠) چرکە. ئەو ئەنجامانەی کە دەست کەوتوون پیشانی دەدەن کە کاریگەری لەرینەوەی ستونی گەورە ترە لە لەرینەوە ی ئاسۆیی، لە هە مو بارە کاندا. بە پێچەواەی ئەوە، لەرینەوەی ئاسۆیی یان تەنیشتی نزمترە و هێمن ترە، لەکاتی هەورازکردنی هەر یەك لەخێرایی بڕین، قوڵایی بڕین، تێکرای دەرخوارد. لە بەرابەردا، لەرینەوەی ستوونی زور شە پۆل دەدات بە زیادکردنی ئەو بگۆرانە.

دراسة الخواص الاهتزازية للغراب الثابت للمخرطة تحت ظروف قطع مختلفة

سفين ياسين قصاب و شيركو عبدالكريم بابان
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الخلاصة

يتناول هذا البحث دراسة خواص الاهتزازات في غراب المتحرك لماكينة الخراطة فى ظروف قطع مختلفة. ومتغيرات القطع المستعملة هي سرعة القطع، عمق القطع و التغذية. تم اختيار الغراب المتحرك لوضع المتحسسات عليه وفي اتجاهين (العمودي و الأفقي) و تم أيظا قياس الاهتزازات خلال عشرة ثواني في الاتجاهين. ومن النتائج التي تم الحصول عليها، يتبين بان تاثير الاهتزازات العمودية أكبر بكثير من تاثير الاهتزازات الجانبية او الافقية عند جميع حالات. و بخلاف الاهتزازات العمودية فان الاهتزازات الجانبية او الأفقية تكون اكثر انخفاضا و اقل اضطرابا عندما تزداد سرعة القطع، عمق القطع أو التغذية، بينما تكون الاهتزازات العمودية اكثر اضطرابا عند زيادة هذه المتغيرات.

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