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Monitoring and Analysis of the Process of Conductive Heating Turning

Tenghui Shen[1, a], Xi Wang[1,b] and Tianyu Zhang[1,c]

[1]College of Physics and Mechanical & Electrical Manufacturing Engineering, Xiamen University

Xiamen, Fujian, China

[a]270907222@qq.com, [b]wangxi3000@xmu.edu.cn, [c]zhangtianyu334@163.com

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Abstract. This paper introduces conductive heat turning method using the high manganese steel as experimental materials.An experimental platform has been established, and vibration signal collected through continuous wavelet transform. By comparing and analyzing different processing parameters and working conditions,the effectiveness of conductive heating turning method's reducing the vibration in the process of turning the size has been proved.

Introduction

Difficult-to-machine materials including high strength, high hardness and high temperature resistance of new materials (such as high strength, high temperature alloy steel, hardened steel, stainless steel, titanium alloys, chilled cast iron and ceramic material, etc.). On processing these materials, there are issues such as large cutting force, high temperature, serious tool wear, and the difference of machining surface quality. The issues produce pollution emissions and the development blockings of modern industry when it's unable to improve the quality of the workpiece. [1]

Through the study, the heating cutting-an effective processing method-one of which is electric heating cutting,has gradually become mature, yet provides a new direction for the machining of the new material . [2]

The Principle of Heating Cutting. Heating cutting is one of the effective methods of difficult-to-machine materials for efficient processing. Heating the cutting material makes the surface layers reach a suitable temperature before the process,and the purpose is to decrease the hardness and strength of the material to help the plastic deformation, which reduces the cutting force and vibration, improve the metal removal rate and prolong the tool life. It also can improve the surface roughness of workpiece machining. [1, 2]

The Principle of EHM Conductive Heating Cutting. the EHM conductive heating cutting method is to make a loop using a cutting tool and workpiece in the condition of low cutting speed, and increase cutting temperature by directly power the tool - artifacts loop on low voltage high current. Through the heating effect of the current auxiliary cutting temperature, cutting zone softening material is heated, the metal hardness decreased, the shear resistance of the material and the cutting force reduced. This also helps improve the processing performance of the workpiece material, make it smooth in cutting, smaller in surface roughness, and machined surface has no hardening or softening phenomenon. [3]

Heating device as Fig. 1 shown, the power supply at one end connected to the carbon brush, the other end connected to the cutting tools, cutting tools and tool rest insulated by mat one insulating layer. When cutting the workpiece, electricity flows through the carbon brush and spindle, chuck and workpiece, cutting tool to form a closed loop. When current flows through the ABC narrow area in this picture, because of its high current density, joule heat is produced,yet the cutting deformation zone is heated. [4]

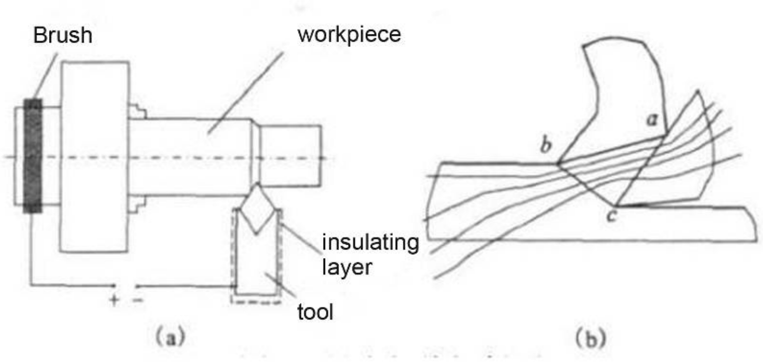

Fig.1 EHM conductive heating turning principle diagram

The experimental method of the conductive heating cutting theory In this paper. The experiment method in this paper differs from EHM method. We use on both ends of the workpiece clamping electrode constitute a loop to complete electric heat, and cutting tool does not participate in conduction. Schematic diagram is as Fig.2follows:

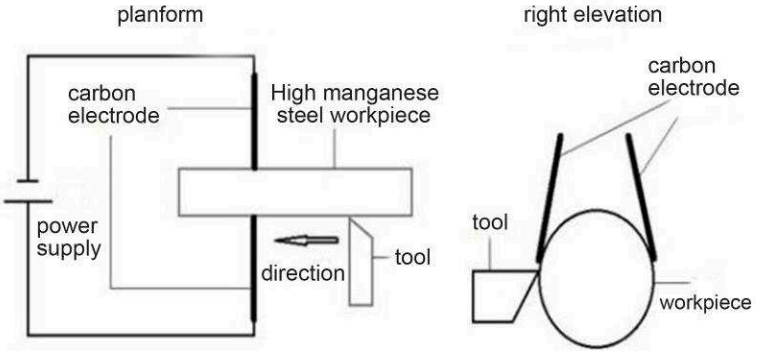

Fig.2 The conductive heating principle diagram in this paper

As shown in fig. 2, a loop is powered by providing low voltage high current through the positive carbon rod - artifacts - negative carbon rod. The resistance heat produced by the current is big enough to heat the contact due to small internal resistance of the metal, and big contact resistance of the cathode carbon rod with workpiece. Contact pointed in the tool path achieves the goal of the cutting zone for heating.

The benefits of this conductive heating method are:

(1) the temperature of cutting tools is controlled without conductive heat. The tool cutting performance and longevity are ensured when metal group is kept away from high temperature.

(2) the heating zone is right on the cutting tool path,thus the heating is more complished and cutting zone has softened before the process.

(3)the experiment is more secure as turning tool and the workpiece is not forming a loop, yet will not produce the phenomenon of leakage.

The experimental device.

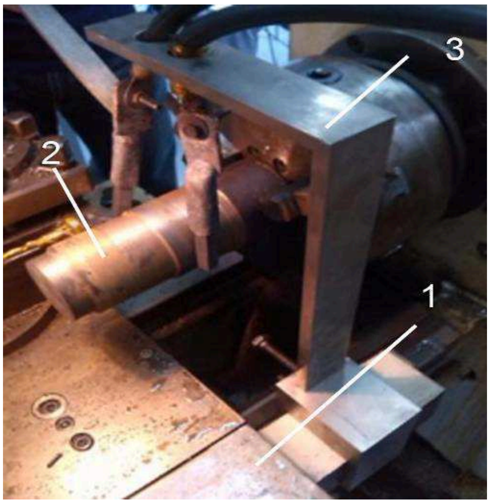

Fig.3 The heating turning device

1. Shenyang machine tool co., LTD manufacture CA6136 series engine lathe, selection of cutting tool is 45 °， cylindrical YW1 car blade.
2. High manganese steel.
3. Support.

Low voltage large current dc power supply. The carbon rods contact the workpiece through the stents as the electrode. Temperature measurement by thermocouple temperature measuring instrument. Vibration sensor model for CA - YD - 1182 type vibration sensor. For the PCI data acquisition card type - 1714 ul data acquisition card, and sampling frequency set to 200 KHZ, single channel. Data collection and processing software is used in the experiment of LabVIEW.

Experimental parameters Settings. This experiment adopted control variable method, and the experiment of the variables involved in a feed rate (Vf) and cutting depth (ap), the spindle speed (n) and heating.

Experiments by the different control variables, vibration data is collected under both the ordinary cutting and electric heating turning cutting methods. Experiment of the specific parameter Settings are as Fig.4 follows:

Serial number	speed of mainshaft (r/min)	Feeding speed (mm/min)	depth of cut (mm)	electricity (A)	voltage (V)	temperature (℃)
1	105	200	1	the ordinary turning		
2	105	320	1			
3	105	400	1			
4	105	320	1.5			
5	105	320	2			
6	205	320	1			
7	290	320	1			
8	105	200	1	240	6.6	700
9	105	320	1	240	6.6	700
10	105	400	1	240	6.6	700
11	105	320	1.5	240	6.6	700
12	105	320	2	240	6.6	700
13	205	320	1	240	6.6	700
14	290	320	1	240	6.6	700

Fig.4The experiment parameter settings

As shown in the table above, 1-7experiments are for un-conductive heating ordinary turning. Speed, feed rate and cutting depth are changed for comparison. 8 to 14 experiments are for conductive heating turning.Speed, feed rate and cutting depth are changed for comparison.

In the experimental group above, the rotational speed, feed rate,and cutting depth between1 and 8, 2 and 9, 3 and 10, 4 and 11, 5 and 7, 6, 12 and 13,and7 and 14 are all the same, the difference lies in whether there is electric heating.Through the data comparison, the vibration size of the conductive heating and the ordinary turning under different experimental parameters can be concluded.

In addition, by testing the hardness of high manganese steel, we see when conductive heating temperature before 700, the hardness of high manganese steel changed little; When 700, hardness change significantly. In order not to damage the internal structure of high manganese steel, we choose 700 as the conductive heating cutting temperature of the experiment.

The experimental data analysis. In this paper, discrete binary wavelet analysis method is used.The continuous wavelet transform $f(x)$ based on the continuous wavelet $\varphi(x)$ is defined as the inner product of $f(x)$ and $\varphi_{a,b}(x)$.

$$W_f(a,b)=\langle f,\varphi_{a,b}\rangle=\int_{-\infty}^{+\infty} f(x)\frac{1}{\sqrt{a}}\varphi(\frac{x-b}{a})dx \qquad (1)$$

Continuous wavelet transform discrete into discrete wavelet transform:

$$\varphi_{m,n}(t)=2^{-m/2}\varphi(2^{-m}t-n),m,n\in Z \qquad (2)$$

First, select the wavelet base. Wavelet base is the basic function of wavelet transform, and the wavelet transform in the basement. Wavelet packet analysis offers a variety of wavelet base [5], and we do data analysis by comparing the choice db5 wavelet base. Second, set the level of decomposition.When the decomposition turns to be 15 layers, the effect is better. So the tentative decomposition is 15, adjustments can be made on different category.

Ordinary cutting and electric heating turning result contrast. Fig.5 shows the comparison of vibration signals in experiment1and 8. Through more than 7 figure of vibration signal analysis, we get the following results: the curve of the conductive heating turning are located below the ordinary turning curve. It shows that Under the same processing parameters, the vibration of the conductive heating turning vibration is smaller than the normal turning, thus proves the effectiveness of the electric heating cutting reducing the vibration in the process.

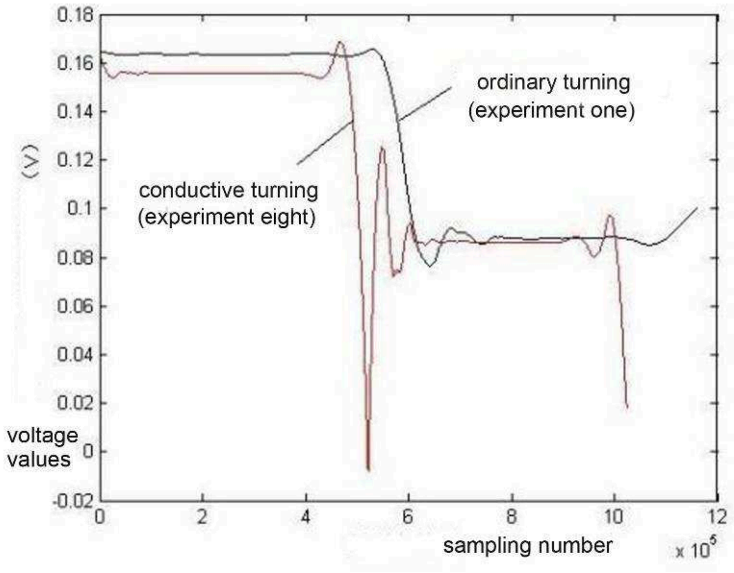

Fig.5 The vibration signal

Under different feed speed signal contrast. Set n=105r/min, ap=1mm。Fig.6 shows the comparison of signals under different feed rate.

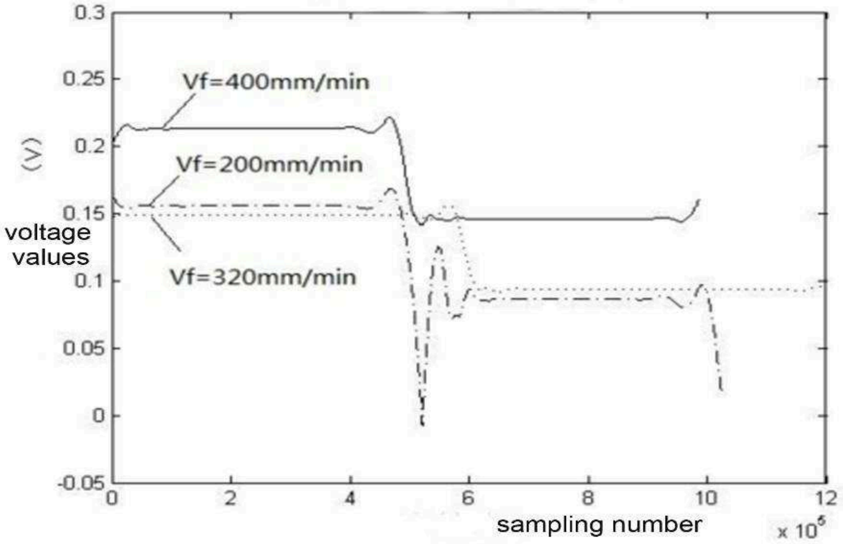

Fig.6 The comparison of signals in different feed rate

From existing knowledge:the greater the feed rate, the bigger vibration. Observed by figure Vf = 400 mm/min, the vibration becomes the biggest on the maximum point; However when Vf = 320 mm/min and Vf = 200 mm/min,the vibration signal difference is not big, and the vibration of the Vf = 200 mm/min even differs larger than this. Probably because in both cases, the vibration is small, so there's not much difference; this phenomenon my be caused by all kinds of error in the process of experiment.

The signal under different cutting depth. Set n=105r/min,Vf=320mm.Fig.7shows the comparison of signals under different cutting depth.

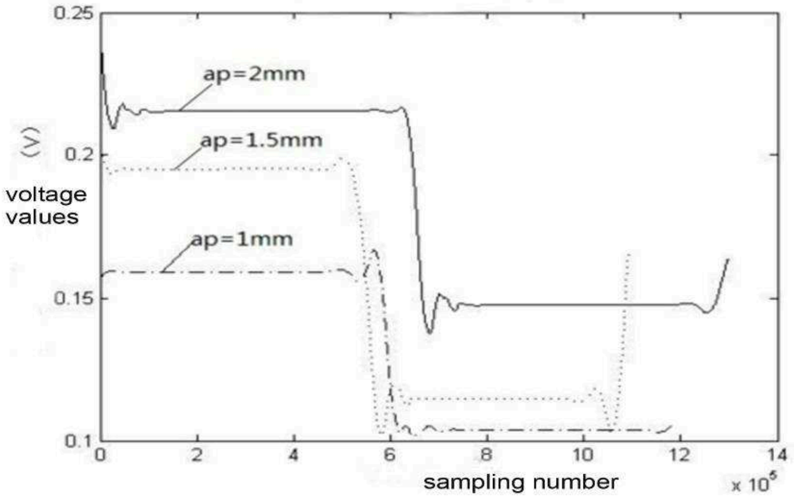

Fig.7 The comparison of signals under different cutting depth

From the above knowledge, the ap = 1 mm is located in the bottom of the curve, the curve of the ap = 2 mm is located on the top;thus when ap = 1 mm, the minimum the vibration, and when ap = 2 mm the vibration is the largest. This shows, under the same condition.the greater conductive heating turning cutting depth, the bigger the vibration.

Under different spindle speed signal contrast. Set Vf=320mm, ap=1mm.Fig.8 shows the comparison of signals under different spindle speed.

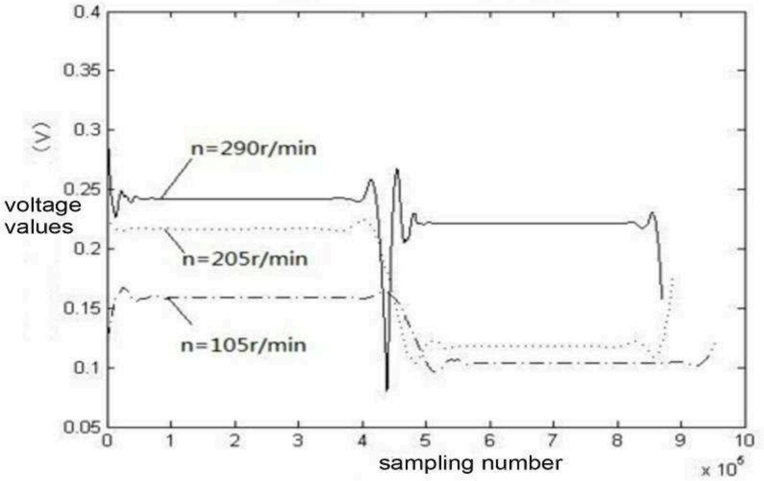

Fig.8 The comparison of signals under different spindle speed

From the above knowledge, point n = 105 r/min is located in the bottom of the curve, point n = 290 r/min is located in the top,;thus when n = 105 r/min, the minimal the vibration; n= 290 r/min, the vibration is the largest. This shows,under same condition, the greater conductive heating turning spindle speed, the bigger the vibration.

Summary

The vibration of the electric heating turning is smaller than common turning.Conductive heat turning method can effectively reduce the vibration in the turning process. The related parameters are spindle speed, cutting depth and feed speed.

References

[1] Dingyi Chen:Difficult-to-machine Materials Research and Development of the Machining [J]. Machine tool, 1985 (5) In Chinese

[2] Kunio Uehara, Hideo Takeshit A. :*Cutting Ceramics with a Technique of Hot Machining*. Annals of the CIRP 1986, 35(1)

[3] Zhejun Yuan:*Metal Cutting Test Technology* [M]. Beijing: Mechanical Industry Publishing House, 1987. In Chinese

[4] M Young.:*the Technical Writer’s Handbook*[M].Mill Valley, CA: *University Science*,1989.[5] R.J. Ong, J.T. Dawley and P.G. Clem: submitted to Journal of Materials Research (2003)

[5] Defeng Zhang:*MATLAB Wavelet Analysis* [M]. Beijing: Mechanical Industry Publishing House, 2009.In Chinese