Jurnal
Teknologi

Full Paper

IMPROVEMENT OF SURFACE ROUGHNESS DURING TURNING OF PRE-HEATED MILD STEEL USING VOICE ACTIVATED ULTRASONIC WAVES

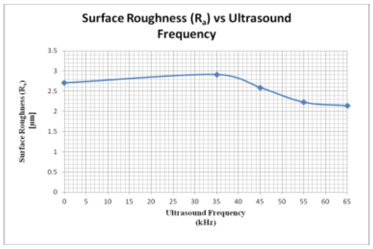
Anayet U Patwari*, Mohammad Ahsan Habib, Md. S. I. Chowdhury, Afzal H. Neelav, Md. Sharfat Latif, T. M. M. Sunny

Department of Mechanical and Chemical Engineering, Islamic University of Technology (IUT), Dhaka, Bangladesh

Article history
Received
31 January 2015
Received in revised form
30 April 2015
Accepted
31 May 2015

*Corresponding author
aupatwari@hotmail.com

Graphical abstract



Abstract

Surface roughness represents the dimensional accuracy of the finished product and is one of the most important quality parameters of the finished product. For improvement of the surface quality several techniques like magnetic field, ultrasonic assisted turning and so on has been introduced. Ultrasonically Assisted Turning has been one of the techniques which showed great promise. It is a hybrid technique based on superimposition of ultrasonic vibration on a movement of a cutting tool in turning process. In this paper, a new technique using the concept of voice activated mode generated ultrasonic smart waves has been proposed and adopted with an aim to improve average surface roughness of the preheated machined surface of mild steel. Externally voice activated ultrasonic sound waves were applied during turning process of preheated mild steel and its effect on average surface roughness was studied. Experimentations were carried out under different ultrasonic frequencies to determine the surface roughness to the best degree possible. The experimental results showed significant improvements in surface roughness in preheated machined products.

Keywords: Voice activated ultrasonic signal, surface roughness, turning, preheated mild steel

1.0 INTRODUCTION

Turning is a form of machining, a material removal process, which is used to create rotational parts by cutting away unwanted material. Scientists have been trying to find relationships between different machining process parameters and their effect on surface roughness and investigating ways to optimize the machining process parameters in order to attain minimal surface roughness. The effect of different machining parameters on stainless steel and brass alloys, during both ultrasonic assisted turning and conventional turning (CT), and evaluated improvements of cutting forces, surface roughness, surface integrity, and machining accuracy was investigated by Mahdy et al. [1]. Abu-Zahra et al. [2] presents an analytical model to monitor the gradual wear of cutting tools, on-line, during turning operations using ultrasound waves. Ultrasound waves at a frequency of 10 MHz were pulsed continuously inside several cutting tools, towards their cutting edge. Physical laws governing the propagation and reflection of ultrasound waves along with geometrical analysis of the wear area were used in deriving the mathematical model. Silberschmidt et al. [3] presents results of analysis of the effect of ultrasonically assisted turning (UAT) on surface roughness (using a broad range of parameters) for a broad range of metals and alloys – from copper, aluminium and stainless steel to Ni- and Ti-based alloys. The effect of machining parameters for both conventional turning and UAT was investigated to provide an optimum range for each material and its relation to surface roughness. An ultrasound online monitoring of crater wear of the uncoated carbide insert during the turning operation is presented by Dinakaran et al. [4]. The method relies on inducing ultrasound waves in the tool, which are reflected by side flank surface. The amount of reflected energy is correlated with crater wear depth. Various ultrasonic parameters are considered for defining the crater wear and individual contribution of each parameter is analyzed. Anayet U Patwari et. al [5] used fixed type 40 KHz ultrasonic signal externally applied on for the improvement of machining responses and found significant improvement during the turning operation of mild steel. Muhammad et al. [6] studied the effect of ultrasonic assisted machining on titanium alloy namely Ti-6Al-2Sn-4Zr-6Mo. An ultrasound-aided deep rolling process (UADR) for anti-fatigue applications was developed by Zhu et al. [7] and used for surface enhancement of titanium alloy specimens. A U. Patwari et al. [8] adopted surface roughness prediction model for machining of Inconel 718 by CNC milling using artificial neural network. As a part of the study, the authors modified their designed controller capable of generated multiple ultrasonic frequencies and adopted a new concept of generating of ultrasonic sound waves using voice command. A voice command activated module is integrated with a developed controller for generating ultrasonic smart waves. The voice activated ultrasound waves were sent from two piezo's from both sides of the cutting tool insert externally during the machining process of preheated mild steel. Surface roughness of the work pieces from each and every experiment was measured and the data were analyzed to obtain the optimum conditions.

2.0 EXPERIMENTAL DETAILS

In this research, experiments were carried out under different ultrasonic frequencies with variations in machining parameters. All the experiments were carried out under dry condition. Feed was fixed at a low value to investigate effect of depth of cut and different voice activated ultrasonic frequencies at a constant cutting speed (530 rpm) for all the experimentation. The process variables with their units (and notations) are listed in Table 1.

Table 1 Process variables and their values

Process Variables		
Spindle Speed (RPM)	**Depth of cut (d)(mm)**	**Ultrasound Frequency (kHz)**
530	0.75, 1	0, 35,45,55,65

Pre-heated mild steel shafts were used as the work piece material of the experiments. The diameter of the shaft was always kept same at 32 mm. The total workpiece length was 200mm. Experimentation length was 150 mm and 50 mm was used for holding the work piece in the chuck.

Figure 1 Prehated work piece used in different experiement

Each experiment was carried out over 50 mm length. Thus three experiments were done on each single work piece. Tungsten carbide coated insert was used in different experiments. Figure 1 shows the preheated workpiece used in these experments.

2.1 Measurement Techniques

To provide the ultrasound frequency, a unique ultrasound device was developed which is able to generate voice activated ultrasound frequency within a range of 1 kHz-70 kHz. The ultrasound generator device developed is able to apply ultrasonic sound waves on the cutting tool insert from both sides. Signal generators were used to produce different ultrasound frequencies. Figure 2 show the schematic diagram of the experimental setup and a labelled diagram of the voice activated ultrasound generator device developed and used in this study respectively. If a person commands through the mouth piece, it accepts the speech and translates into machine language by using a program written in it. So it works through voice activated controller. The centre lathe used was manufactured by Gate Inc., Model L-1/180. Figure 3 shows the calibartion sequence of the voice activated controller used in this study. Different input signals used in this experiment were calibrated accordingly.

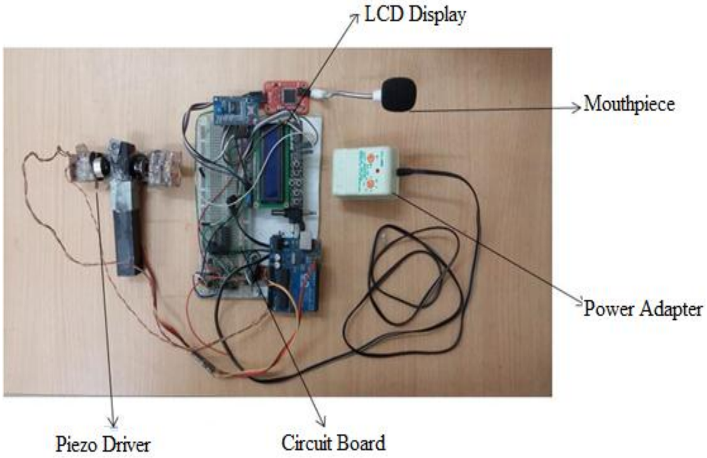
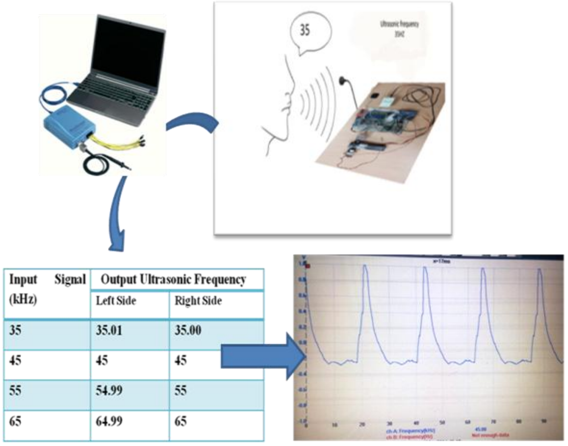


Figure 2 Labelled ultrasound generator device developed specifically for this research with mouth piece configuration

The device developed was calibrated to ensure the correct ultrasound frequency transmitted in the cutting zone. Different ultrasound frequencies were checked using the mouthpiece with a Pico-scope 3204 to ensure that there were no error in the input signal and the out ultrasound frequency. The Mitutoyo SURFTEST SJ-210, a contact profilometer, was used in this study to measure the surface roughness of the machined surface. Here, a stylus is moved vertically in contact with a sample and then moved laterally across the sample for a specified distance and specified contact force. It can measure small surface variations in vertical stylus displacement as a function of position. The height position of the stylus generates an analog signal which is converted into a digital signal stored, analyzed and displayed. In this study, values of Ra, Rq, Rz, assessed surface roughness profiles and BAC and ADC curves were measured with the profilometer. For capturing images of surfaces, optical microscope was used. The model of the optical microscope was "METALLURGICAL MICROSCOPE MMB2300". The magnification used was 100X.



Input Signal (kHz)	Output Ultrasonic Frequency	
	Left Side	Right Side
35	35.01	35.00
45	45	45
55	54.99	55
65	64.99	65

Figure 3 Flow sequence of calibration operation

3.0 RESULTS AND DISCUSSIONS

Figure 4 depicts the results obtained for different combinations of experiments. From the graph for changing the different ultrasonic frequencies for the same feed and cutting speed a comparative idea was obtained. It has been observed that with the increase of ultrasonic frequencies the average surface roughness was gradually improved in case of a prtehetaed mild steel. From the graph it can be seen that for 35 kHz ultrasound frequency, the surface roughness incresae a bit in comparison to the surface quality at normal cutting. But from 45 kHz voice activated ultrasound frequency and onwards the surface quality improves and the surface roughness values are less than that obtained during normal machining.

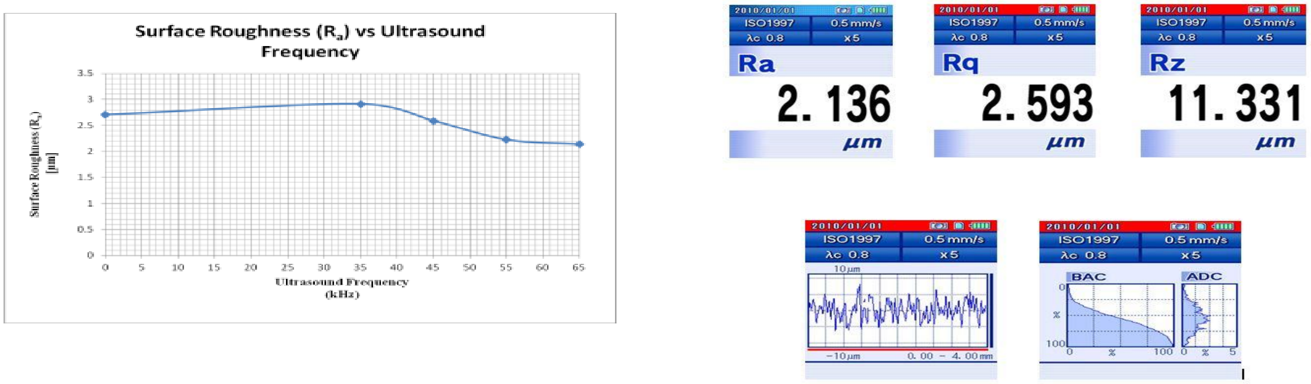


Figure 4 Surface roughness data at 1.0 mm depth of cut for different ultrasound frequencies

This improvement in surface roughness can be explained in relation to chatter reduction. Chatter occurs due to resonance occurring at certain machining frequencies. Application of external ultrasound acts as an additional source to shift the resonance zone from the current trend. The best results are obtained at ultrasound frequency of 65 kHz for machining of preheated mild steel.

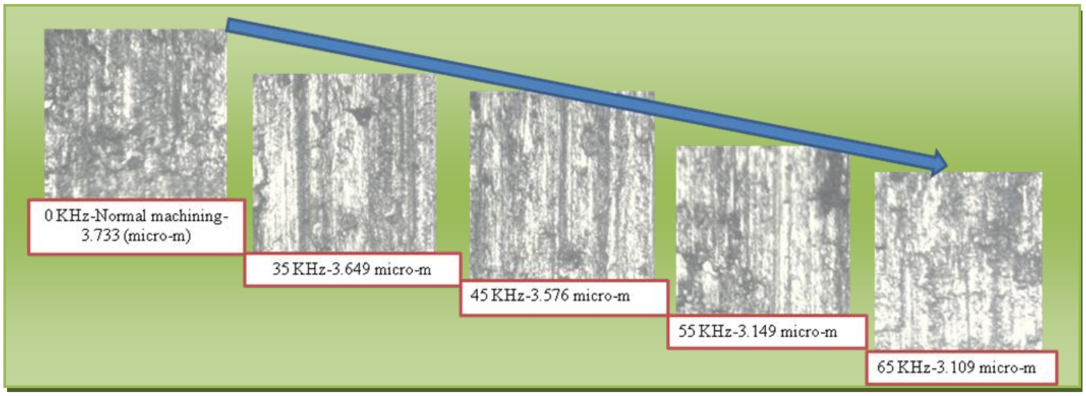


Figure 5 Surface roughness data and surface profile at 0.75 mm depth of cut for different ultrasound frequencies at 530 rpm

To observe the effect of depth of cut on surface roughness in the prehetaed mild steel workpiece another set of experiments were conducted at depth of cut 0.75 mm keeping the cutting speed and feed same. Feed was set at low value to find the effects. Similar trends were observed that with the incresae of voice activated ultrasonic frequencies surface profile was improved. The different surface profile observed under the optical microscope and their corresponding surface roughness values are shown in Figure 5. At 65 KHz ultrasonic frequency better surface roughness was observed compared to other frequencies and normal machining. But the surface roughness values is comparatively higher than that of the values obtained at 1 mm depth of cut which shows a similar findings by Amin et al. [9] for turning of steel at low feed. But it is clearly found that voice activated assisted machining process is a very effective method for the improvement of surface roughness.

4.0 CONCLUSION

The application of voice activated external applied ultrasonic signals has significant effect in improving the average surface roughness in dry turning operation of preheated mild steel. This can be explained by the reduction of the vibration of tool and work piece system in case of voice activated ultrasonic sound wave. It was found that ultrasound frequency of 45 kHz or above gives better surface roughness in comparison to normal machining at different combinations of cutting parameters. The best results are obtained at ultrasound frequency of 65 kHz.

References

[1] Mahdy, S. M. A., Gouda, M. A., Silberschmidt, V. V. 2013. Study of Ultrasonically Assisted Turning of Stainless Steel and

Brass Alloys. *In: Journal of Physics: Conference Series 451*, paper 012037.

[2] Nidal H Abu-Zahra, Gang Yu. 2000. Analytical Model for Tool Wear Monitoring in Turning Operations using Ultrasound Waves. *International Journal of Machine Tools and Manufacture*. 40(11): 1619–1635.

[3] Silberschmidta, V.V, Mahdyb, S.M.A., Goudab, M.A., Naseera, A., Agostino Maurottoa, A. Roya, A. 2014. Surface-Roughness Improvement in Ultrasonically Assisted Turning. *In: 2nd CIRP Conference on Surface Integrity (CSI), Procedia CIRP*. 13: 49-54.

[4] D. Dinakaran, S. Sampathkumar, N. Sivashanmugam. 2009. An Experimental Investigation on Monitoring of Crater Wear in Turning using Ultrasonic Technique. *International Journal of Machine Tools and Manufacture*. 49(15): 1234–1237.

[5] Md. Anayet U. Patwari, Shafi Noor, Omar Farque Rassel, TMM Sunny. 2013. Effect of Ultrasonic Sound Signal on Machinability Control During Turning Operations of Mild Steel. *International journal of Electrical Energy*. 1(2): 113-116. Engineering and Technology Publishing, doi: 10.12720/ijoee.1.2.113-116.

[6] Muhammad, R., Maurotto, A., Roy, A., Silberschmidt, V.V. 2012. Ultrasonically Assisted Turning of Ti-6Al-2Sn-4Zr-6Mo. *In: Journal of Physics: Conference Series 382*. paper 012016.

[7] You-Li Zhu, Kan Wang, Li Li, Yuan-Lin Huang. 2009. Evaluation of an Ultrasound-Aided Deep Rolling Process for Anti-Fatigue Applications. *Journal of Materials Engineering and Performance*. 18(8): 1036-1040.

[8] Mi Hossain, Akm Amin, Au Patwari Computer and Communication Engineering. 2008. ICCCE 2008. Development of an Artificial Neural Network Algorithm for Predicting the Surface Roughness in End Milling of Inconel 718 Alloy.

[9] Kok P.Y., Amin A.K.M.N. and Ahmad F. Ismail. 2005. Preheating, Cryogenic Cooling and Combined Approach to Improve Machinability of Stainless Steel in Turning. *Proceedings of the International Conference on Mechanical Engineering 2005 (ICME2005) 28- 30 December 2005*. Dhaka, Bangladesh, ICME05-AM-49.