SPECIFICITIES OF PRODUCED MACHINED SURFACE MICROTOPOGRAPHY AT USV-ASSISTED CUTTING

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Abstract: *The article considers the issues on interaction of cutting wedge and machining material at the assistance of spacial high-frequency self-vibrations of tangible amplitudes superimposed on the USV cutting process of radial, tangential and axial directions which is important from the aspect of the machined surface produced.*

Introduction

Producing of machined by edge-cutting surface topography, inherently, is an uncontrolled process which depends on multiple factors conditioned by physical and mechanical properties of contacting bodies, friction, seizure events, etc.

The analysis of stereometric contact of tool cutting wedge with the machining material, kinematics and cutting parameters allows at first appriximation to assess the eventual topography of the surface produced. Though, in fact, the topography of the surface is produced not as we expected just only for the mere reason that at cutting the vibrations and self-oscillations are unavidable, i.e. the kinematics of geometry generation in the microtopography-demension scale quite differs from the adjustable parameter-based cutting. At the USV superposition on the cutting process it was definitely observed that the tangible self-oscillations of the machining structure dampen which can lead to changes in the machined surface roughness and wear pattern of the cutting wedge. That in its turn allows to provide improved data of the machined surface quality and demensional durability of cutting wedge at the USV definite amplitudes.

It is worth mentioning, that the self-vibrations of the machining structure is a complicated spacial pattern which parameters depend on the stiffness of machining system directed along the cutting coordiate system, which can be purposefully affected. From this aspects it is reasonable to study the effect of the USV specifically directed on the conditions of the produced machined surface microtopography, cutting kinematics and tool wear-out process when it operates in the known stiff system of machining and high-frequency vibrations of the machining system go with the ultrasonic (US) frequency spectrum. This issue is actual on the assumption of tendency in increasing demands on the accuracy and quality of the machined surface of the metal products.

We studied the effect of forced USV of cutting wedge on the cutting process at turning and regularities of changes in conditions of machined surface production at turning on 1M61 machine (Fig.1) the ring blanks, in 36 mm diameter, made from 45, ШХ15, 12Х18Н9Т steel brands, ВТ5, ВТ10 titanium alloys and ЛС59 brass, as well as at scraping gray cast iron, 45 steel and БРАЖ bronze [1,2]. At turning the cutting rate variated in the speed limits typical of wide-range auto-vibration generation at cutting hard-to-machine materials. The depth of cutting was 0.25-1.00 mm. The feed rate was 0.08-0.42 mm/r, the USV frequency - 18.5 kHz, amplitude - 3-10 micrometers. The research involved also investigations at carrying out scraping by using ultrasonic scraper [3]. The cutting mode parameters were chosen according to the recommendations, rather “modest” ones. Therefore, we can state that such interesting process like featheredge edge cutting by the wedge with circular cutting edge and front cylindric face has not been actually considered.

The cutter heads for US cutting were sharpend with diamond cup wheel, on the cutter-grinding machine. The accuracy of the wedge top position to the base surfaces of the cutting head made up =1 micrometer according to which it had been set on the US tool transmitter.

Beneath, we bring the microphotographs of qualitative changes of machined surface microtopography demonstrating the detected peculiarities of changes in conditions of machined surface production (Fig. 2) based on which we carried out the detail evaluation of produced topography and characteristics of workhardening of machined surfaces. The analysis of the microphotographs of the machined surfaces definitely shows that with the acoustic energy feeding the self-oscilation of SPEED system practically instantaneously dampen already in the time interval of one rotation of the workpiece, i.e. in the interval less than 0.1 sec.

The analysis of specimens shows that this time interval is much shorter since dampening occurs in the part of one rotation, at $20\text{-}90^0$ turn angle. It means that the acoustic system provides amplitude rise to the specified in the time interval of several dozens of ultrasonic vibrations of cutting wedge, at that generated by the very process of cutting at sufficient dynamic loads. To check the same at lower loads we recorded the USV amplitude rise at scaping which showed that the amplitude rise occured within 8-15 oscilations of the acoustic system, i.e. during microseconds. Thus, the US cutting in the context of response to the fluctuation in the machining material and machining system can react to the linear fluctuations of several micometers, as well as to the kinematic fluctuations as long as up to one microsecond. The test setup for USV – assisted scraping and microphotographs of scraped tracks with the superimposition of the USV are presented below (Fig. 3).

Fig. 1. Test setup for studying the USV-assisted cutting processes and special cutting heads

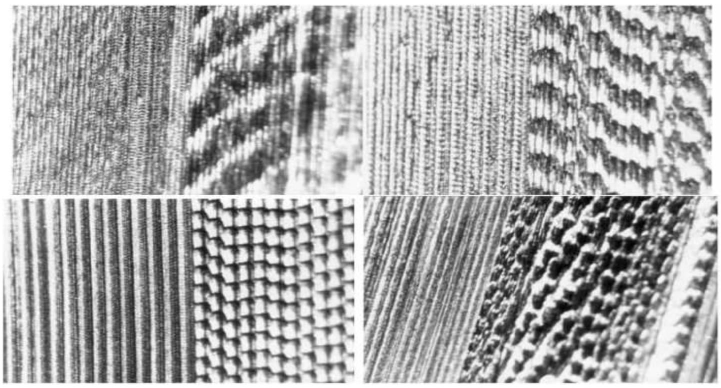

Fig. 2. Machined surfaces. Conventional cutting at the availability of evident SPEED sytem auto-vibrations (on the right). Machined surfaces after USV feeding (on the left)

To conduct the pilot research we designed the test setup which allows to imitate the scraping operations to within its peculiarities when the scraper performs the tool penetration at about 15-22 mm long cutting path and smoothly withdraw it from the process of cutting. Timing of peculiarities of this operation performed by different scrapers showed that cutting process, i.e. the scraper angle-cutting path dependency, can be identified at adequate accuracy with the cosine mechanism which served as basis for the designed test setup. The test setup was designed proceeding from the

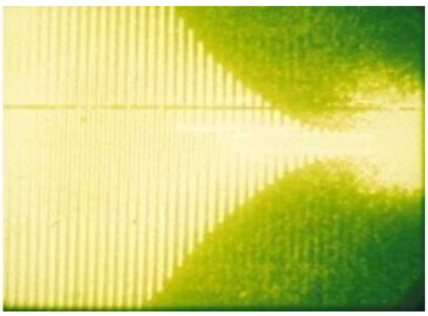

Fig. 3. Amplitude rise up of the USV tool at scraping

purpose to provide maximum feasibility to investigate featheredge machining by cutting considering the fact that ultimate individualized benchwork machining by cutting actually has not been investigated. Therefore, we provided the test setup circuit with wide-range capacity to control movement and cutting parameters. The modes provided by the test setup are as follows: constant edge tilt angle - and fixed speeds and cutting direction in the range of line feed of the redesigned milling machine; constant edge tilt angle - and fixed speeds of complicated 2D cutting in the range of possibilities of line and cross feedings of milling machine; variable edge tilt angle – and variable cutting speed with single-coordinate motion of cutting in the range of vertical feed of milling machine at providing cosine dependences; variable angle – and cutting speed by providing cosine-sine dependences; variable angle – and cutting speed with engaging in cosine-sine dependence strictly defined speeds provided by jaws of different profiles; the same mentioned in items 3,4,5,6 at using 2D-cutting when the movement by the second coordinate has fixed speed in the range of cross feeding of the redesigned milling machine. To provide the mentioned modes of machining the test setup was equipped with sine mechanism, special drive with profiled drum with variable eccentricity, including some modification of milling machine drive in order to provide cutting speed range typical of scraping process.

The carried out investigations of scraping process and theoretical analysis of interaction of circular edge and machining material allow us to reveal the regularities of variations of cutting layer cross section subject to the angular change, including the value and forms of contact area along the front cylindrical surface of wedge, specificity of dynamics and kinematics of featheredge cutting process at scraping, as well as the USV effect specificities on the dynamics and kinematics of the process.

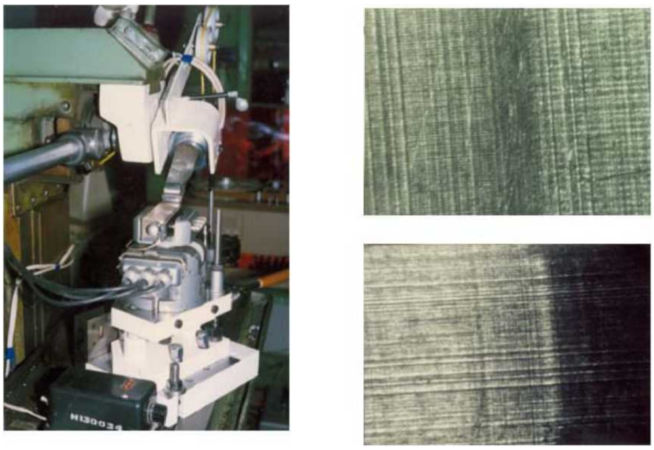

Fig. 3. Test setup for scraping with USV and microphotographs of scraped track with superimposition of the USV of different amplitudes

It was justified that the main parameters of scraping process control is the wedge back angle and kinematical back angle the values of which can be controlled. Such control is actually performed by a scraper, probably automatically, though the control level characterizes the scraper qualification. The obtained results give hope that scraping process can be mechanized and partially automated which until now has actually failed in providing desirable results whereas this process is quite common if considering also the recovery works.

References: 1. Khristaforyan S.Sh. Theoretic and engineering principles of increasing effectiveness of machining by using the USV // T.S. Doctoral thesis на соиск. -Yerevan, -1996. **2.** Khristaforyan E.S. Improvement of scraping process by USV assistance //T.S. Candidate thesis, Yerevan, - 2001. **3.** Gasparyan P. Ju. Increasing efficiency of using edge tool potential under conditions of flexible production systems// T.S. Candidate thesis, Yerevan,- 2009.