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ANALYSIS OF SURFACE ROUGHNESS PROFILE MACHINING BY ULTRASONIC LAPPING

TULCAN, L[iliana]; TULCAN, A[urel]; TURC, C[ristian] - G[heorghe] & STAN, D[aniel] V[oicu]

Abstract: *The aim of the experimental research performed in the paper consists in more objective functions investigation that characterized the quality of surface machining by ultrasonic aided plane lapping from roughness parameters point of view. The statistical analysis of surface roughness profile permits distribution and the shape of ultrasonic aided lapping surface irregularities evaluation and become a more complete capitalization of performed experiments.*
Key words: *ultrasonic lapping, surface roughness profile*

1. INTRODUCTION

Any abrasion process is influenced by concerted action of four entrance categories: abrasive tool or abrasive compound, the machine tool, the workpiece and operational factors. The process seems to be complex and difficult to be described. The multitude of lapping influence factors cumulated by ultrasonic field characteristic parameters lead to the apparition of some complex, interconnected phenomenon in the work area, where is difficult to define an analytic model, but sometime is lend oneself to experimental modeling. Although there are some theoretical and experimental researches, this procedure is less known and especially less applied. It is estimated that there are several research direction for improving the process (Tulcan, 2000), (Amza, 2006), (Nanu et al., 2004). The goal of the research is the optimization criteria of quality and productivity of the process.

2. EXPERIMENTAL DESIGN

Experimental tests were performed by adapting an experimental ultrasonic drilling machine as a plane-lapping machine with ultrasonic activation of the workpiece. This equipment permits to obtain the specific cinematic of lapping process (figure 1). The experimental program is based on the experimental design. This offers the possibility to obtain empirical models for the influence factors area, with a shortened number of tests, but with high experimentation efficiency (Cicală, 1999). The experiment program pursues the analysis for 15 objective functions parameters, the shape of profile micro-irregularities parameters, grouped into 3

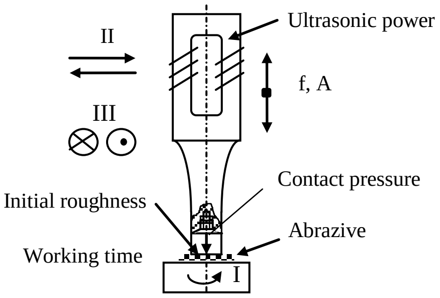

Fig. 1. The influence factors selected

categories: the high of profile micro-irregularities technological and functional parameters. Three of them were considered the most practical interest: the surface roughness Ra [μm], processing at a bearing length ratio cut to 50% $t_{p0,5}$ [%] and productivity Q_s [%]. The productivity is expressed as percentage decrease of roughness.

The significant factors selected after random balance for factorial experiment were working time t[min], abrasive grains nature [Mohs hardness], initial roughness R_{ai} [μm], ultrasonic power P[W] and contact pressure p [MPa] (figure 1, table1).

		Physical Value				
Parameter	Coding value	t [min]	Abr [Mohs hardness]	R_{ai} [μm]	P [W]	p [MPa]
Central point	0	12	9.3	2.0	25	0.0865
variation interval	Δ	4	0.3	1.2	25	0.0235
Upper level	+1	16	B_4C-9.6	3.2	50	0.110
Less level	-1	8	Al_2O_3 -9.0	0.8	0	0.063

Tab. 1. The influence factors and their variation intervals

Fractional experimental design 2^{5-1}, with a number of N = 16 experiments and 3 relied experiments in the central point was designed. All the figures present a sample for the final roughness R_{af}= 0,16 μm resulted after the factorial experiment. Figure 2 shows the surface profile that was the base to measure and calculates the objective functions. Figure 3 shows the bearing length ratio for different cutting depths.

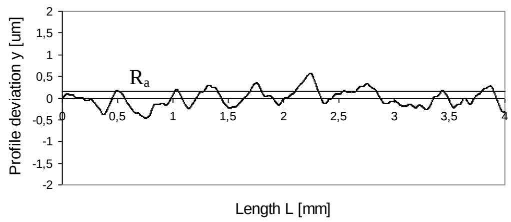

Fig. 2. Roughness profile

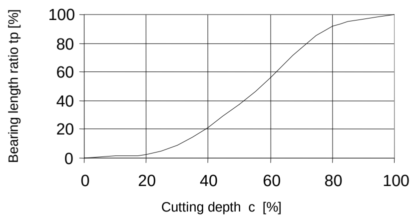

Fig. 3. Bearing length ratio of the profile

3. SURFACE ROUGHNESS PROFILE ANALYSIS

Application random functions theory to study the parameters of surface roughness profile, as current approach, admits a fine and complete estimation of the high of roughness parameters and a spatial distribution of surface micro-irregularities. It considers the surface roughness profile like a time series. Profile's irregularities study using random functions (Zsivanov, 1998) involves:

- the distribution analysis of the profile height irregularities. The control of normality repartitions of analyzed surface profile deviations is achieved by comparing the empirical repartition and theoretical – normal – repartition and determination of skewness and kurtosis coefficients of empirical distribution referring to theoretical distributions.
- the spatial distribution analysis of the profile height irregularities. The autocorrelation functions r(t) and power spectral density functions D(k) are determined.

The graphical representations, using Statgraphics™ software, of the autocorrelation functions for 1000 intervals is shown in figure 4 and the control of normality repartitions for 2000 deviations on 4 mm evaluation length is shown in figure 5. In the factorial design, the skewness and kurtosis coefficients were considered and analyzed.

For graphical-analytical determination of the autocorrelation functions and power spectral density functions it was applied the particular points roughness profile method which operate with punctual indicators of surface roughness profile: number of intersections of the profile to median line, number of profile projections, number of profile inflexions. The functions r(t) and D(k) are illustrated in figure 6 and figure 7.

The statistical analysis of spatial distribution of the high of profile irregularities has, at base, the profile shape comparison with itself, shifted by a certain step, establishing the correlation

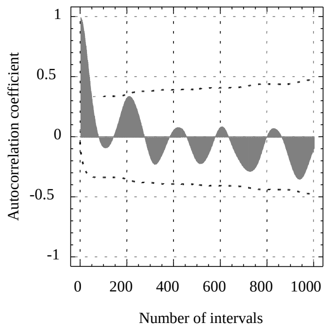

Fig. 4. Autocorrelation functions

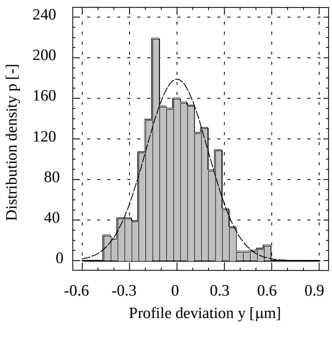

Fig. 5. Profile deviation distribution

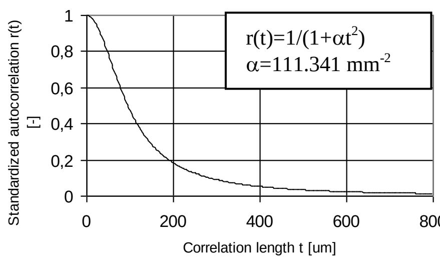

Fig. 6. Standardized autocorrelation function

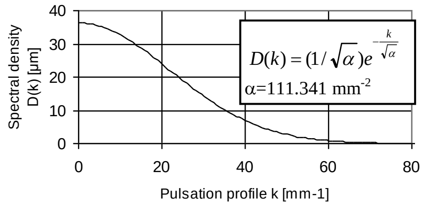

Fig. 7. Spectral density function

degree through the two points of the roughness profile, situated on ***t*** distance one to each other. When the superposition of profiles is the best, the autocorrelation functions are proximity to 1. An oscillatory component present on this function indicates a roughness periodicity (Zsivanov, 1998).

4. CONCLUSIONS

Comparing several experimental samples machining aided ultrasound or not for several levels of the other influence factors, it is point out that random component share is bigger on ultrasonic aided samples. Most abrasive grains have chaotic movements by ultrasonic field action. At dilatation and compression phases of abrasive compounds existing between lap disk and processed surface, the abrasive grains relative speed varies more, on more complexes trajectories, increase the grains number that rolls and decreases the grains that slip.

Analyzing how the other influence factors modify the surface roughness profile structure, it appears that higher processing time also causes a random spatial structure, which is justified because by increasing the time, abrasive grains become smaller and lighter with more rounded edges and thus made more rotational and rolling motion. For the remaining factors in the given experimental conditions, no significant correlation was evident in the estimate of random or regular component of the roughness profile. Results obtained reflect sensitivity to the action of ultrasonic oscillation introduced into the work area. Further research will be to carry out factorial design for different materials and surfaces shape.

5. ACKNOWLEDGEMENTS

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6. REFERENCES

Amza, Gh. (2006). *Ultrasunetele aplicaţii active (Ultrasound active applications)*, Editura AGIR, ISBN 973-720-096-9, Bucharest

Cicală, E.F. (1999). *Metode de prelucrare statistică a datelor experimentale (Methods of statistical processing of experimental data)*, Editura Politehnica, ISBN 973-9389-30-8, Timisoara

Nanu, A., Marinescu N. I. et al. (2004). *Prelucrarea prin eroziune cu unde ultrasonice (Erosion with ultrasonic waves)*, Editura BREN, ISBN 973-648-385-1, Bucharest

Tulcan, L. (2000). *Activarea ultrasonică a proceselor de netezire fină abrazivă (Ultrasonic activation of fine abrasion processes)*, Doctoral thesis, Timisoara

Zsivanov, D. (1998). *Contribuţii la evaluarea caracteristicilor suprafeţelor de contact cu rugozitate izotropă (Contributions to assess characteristics of the contact surfaces with isotropic roughness)*. Doctoral thesis, Timisoara