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3D SURFACE TOPOGRAPHY ANALYSIS OF ENVIRONMENTALLY CONSCIOUSLY DRILLED HOLES

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ABSTRACT: Nowadays a widely spreading group of technologies for reducing environmental pollution in mechanical industry is machining with minimal quantity lubrication. Besides environmental benefits of such technologies reducing tool lifetime is a serious disadvantage, and surface quality also raises questions. In this study experimental examination of surface roughness of holes made by environmentally friendly drilling into cast iron workpiece is performed. It is shown the effect of the adjusted technological parameters on the machined surface quality of the hole.

KEYWORDS: environmental pollution, surface quality, roughness parameters

INTRODUCTION

The global phenomenon of increasing environmental pollution necessitates engineers to organize and develop production technologies in an environment conscious way [1, 2, 3]. In last centuries many kinds of coolants and lubricants were applied in high quantity for make production more effective. However these materials have several disadvantageous properties besides their unquestionable useful features. Today engineers make efforts to eliminate these disadvantages by seeking for new methods and solutions. Amongst these researches there were several investigations on decrease or surrender the use of coolants and lubricants in cutting technologies [4, 5, 6].

Dry machining is applied in increasing frequency in industry. Minimal lubrication technologies are also frequently applied, but main obstacle of its application is that mechanism of this type of machining is not completely clarified recently. This is one of the most intensive research area of cutting theory today.

Authors have published results on 2D surface roughness study in references [7, 8]. Roughness parameters as function of technological parameters and volume of coolants and lubricants were studied. Surface roughness is also important in laser cutting. Madic et al. [9] developed a neural network algorithm for optimizing parameters of CO_2 laser cutting for surface quality.

EXPERIMENTS

Twist drill used for to the experiments has type Gühring WRDG DIN 6537 (monolith carbide, TiAlN, inner drains for coolants and lubricants) with the diameter of Ø10.2mm and tool material was K20. Material of drilled test specimen was grey cast iron EN-GJL-200 (MSZ EN 1561). A series of drilling experiments were performed, the length of the holes was 30mm.

Outer minimal lubrication was realized by a „NOGA MINI COOL” machine. „OMV cut XU” type chlorine-free oil was applied for lubrication.

Experiments were performed by an MU-250 type milling machine with following cutting parameters:

Revolution number of spindle of milling machine:	*n=2250 rev/min*
Feed rate:	f_1*=0.18 mm/rev and* f_2*=0.35 mm/rev*
Cutting speed	v_c*=72.06 m/min*
Volume of coolants and lubricants:	$\dot{V}_{oil,1} = 0cm^3/h$ *(dry) and* $\dot{V}_{oil,2} = 28cm^3/h$
Feed velocity:	v_f *= 405 mm/min*
Main production time:	t_1 *= 0.074 min and* t_2 *= 0.044 min*

For evaluation of results an AltiSurf®520 3D surface roughness measuring equipment was used at the Department of Production Engineering in University of Miskolc.

A research work at University of Birmingham in the frame of tender of European Community [Directorate of the EC (DG12)] substantially contributed to develop application of 3D surface visualization technologies and determine surface parameters. Closing report of this project defines so-called „Birmingham 14 parameters" for featuring surface quality [10, 11].

Further development of these results is described in standard ISO 25178. Reference [12] serves useful details in this topic.

THE 3D AMPLITUDE PARAMETERS AND THEIR EVALUATION IN CASE OF DRILLING

AltiSurf®520 3D surface roughness measurement equipment was applied for measuring surface roughness parameters (Fig. 1).

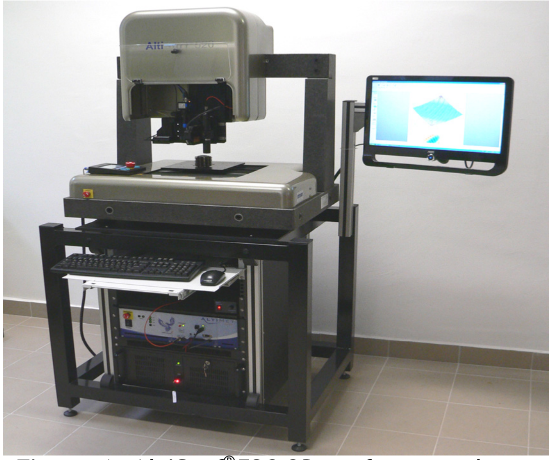
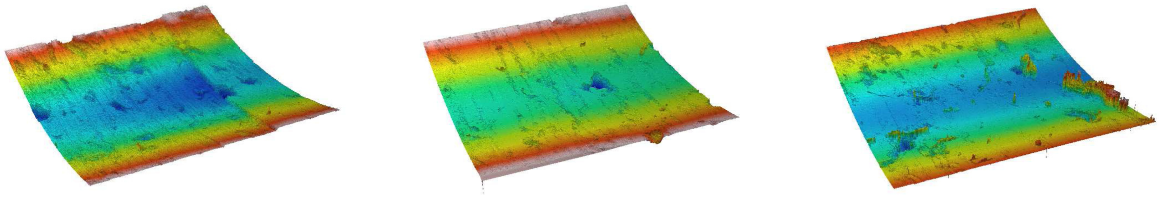


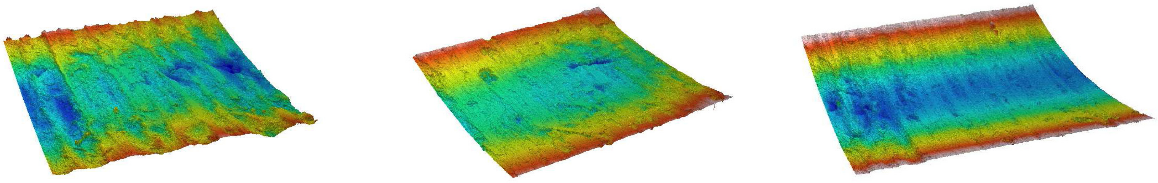
Figure 1. AltiSurf®520 3D surface roughness measuring system

Measured area on drilled holes had dimensions of 2 mm x 2 mm. Figures 2 and 3 show 3D graphical representations of different measurements performed. Fig. 4 summarizes roughness amplitude parameters as function of drilled length belonging to cases of Fig. 2.



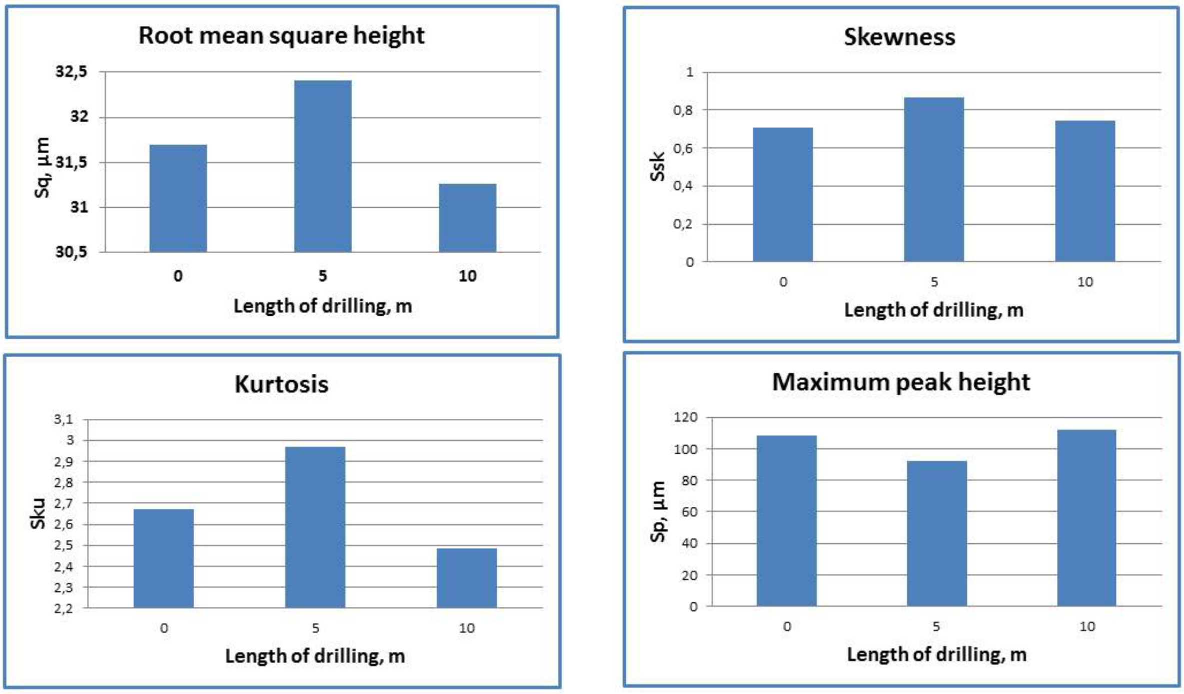
l =0 m *l =5 m* *l =10 m*

Figure 2. 3D surface roughness pictures in case of different drilled length (d) (f_2=0.35 mm/rev; $V_{oil,1}$=0,0cm^3/h)



l =0 m *l =10 m* *l =15 m*

Figure 3. 3D surface roughness pictures in case of different drilled length (d) (f_1=0.18 mm/rev; $V_{oil,2}$=28 cm^3/h)



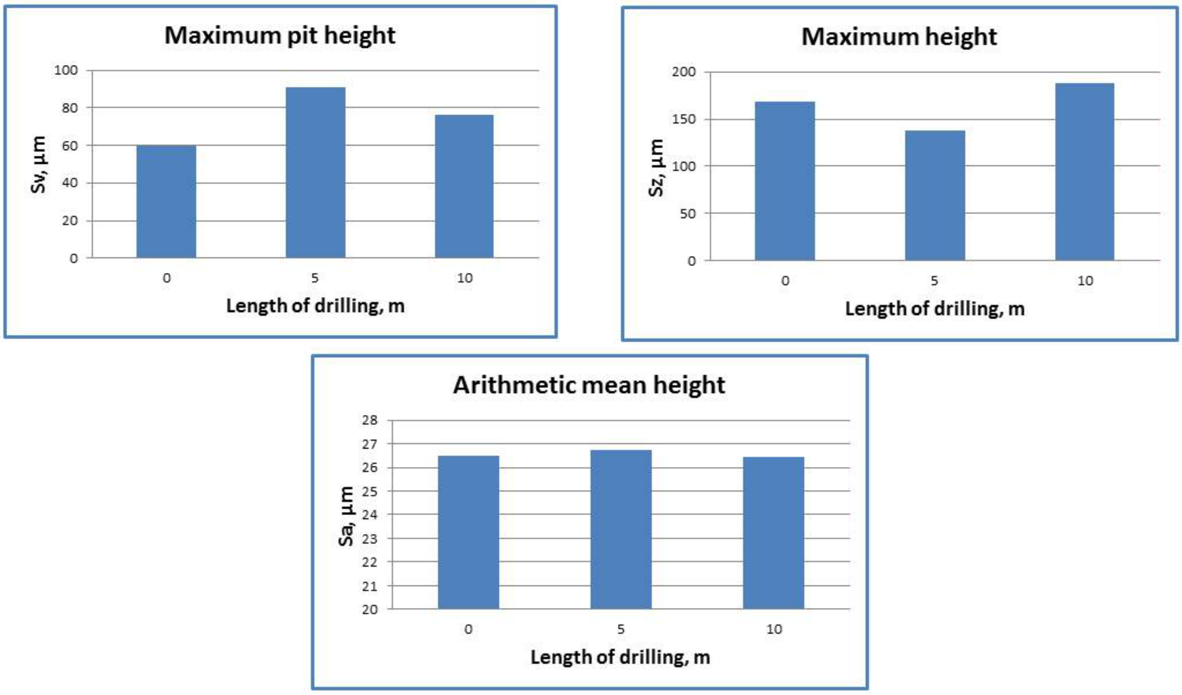
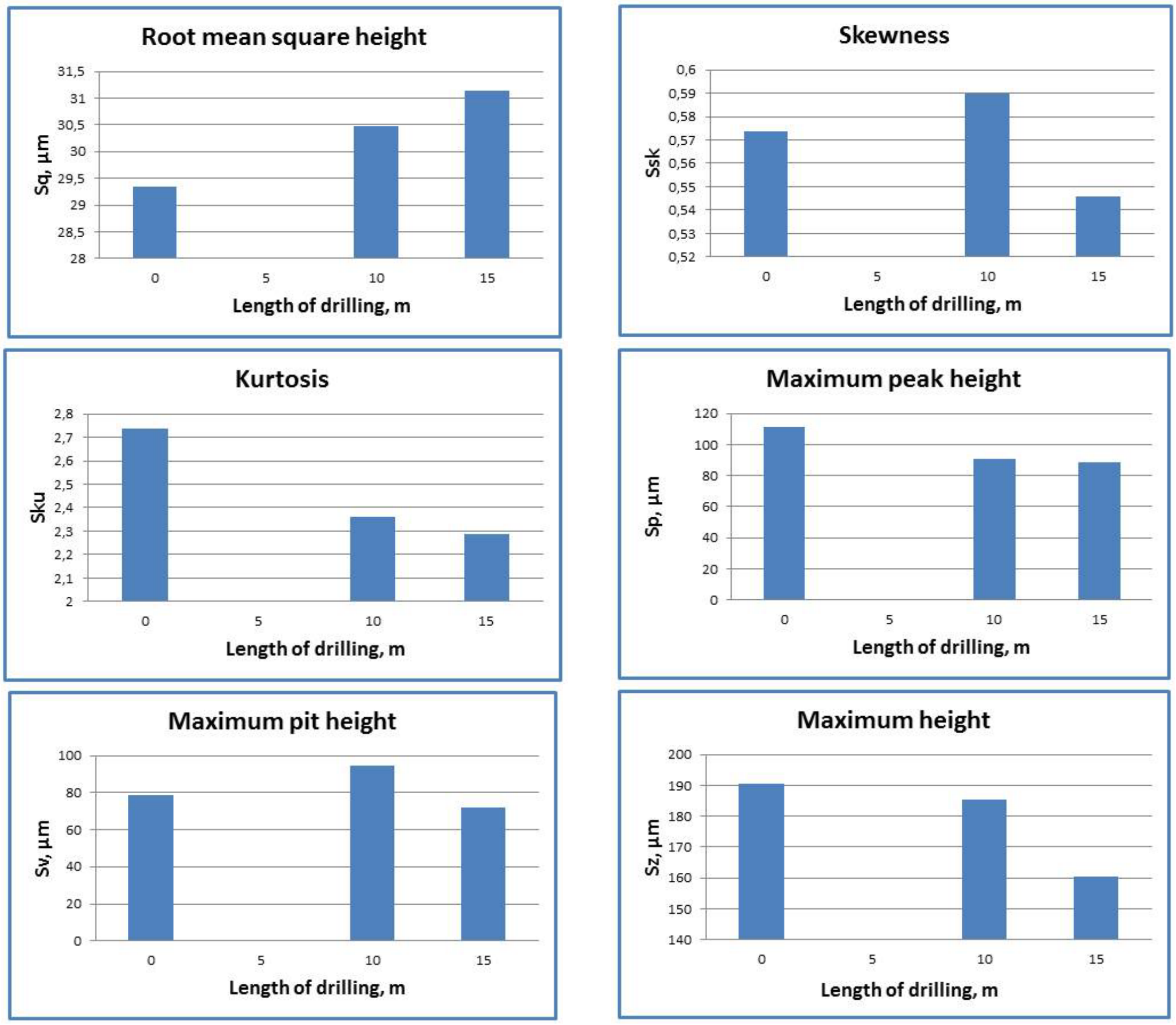


Figure 4 3D surface roughness parameters as functions of drilled length
(f_2=0.35 mm/rev; $V_{oil,1}$=0,0cm^3/h)

For detailed explanation of two-dimensional surface roughness parameters the reader can refer to [7]. Fig. 5 summarizes roughness amplitude parameters as function of drilled length belonging to cases of Fig. 3. Specimen belonging to drilled length 5m failed, so these data are missing from the evaluation.



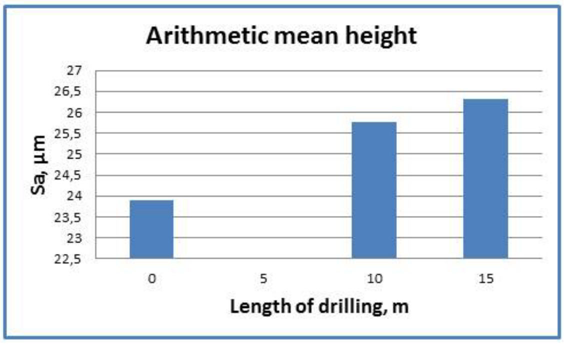
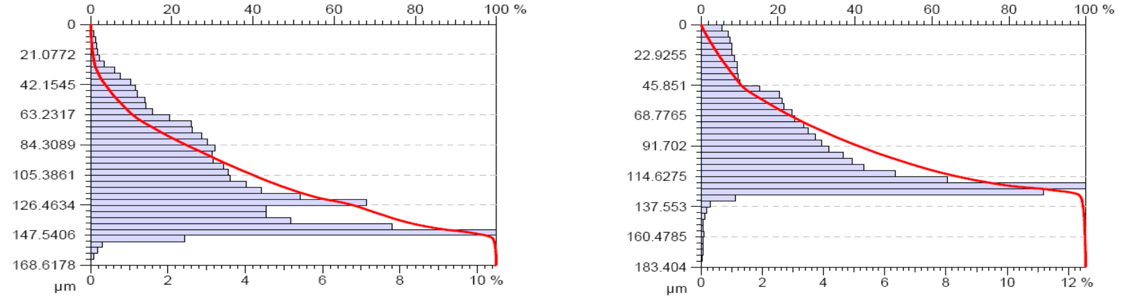
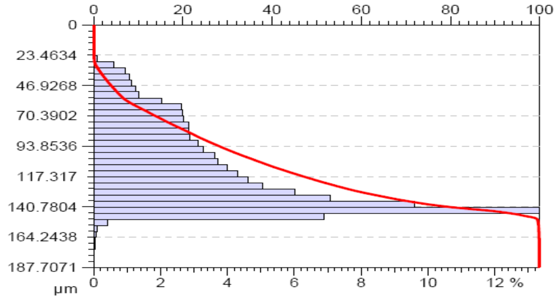


Figure 5. 3D surface roughness parameters as functions of drilled length
(f_1=0.18 mm/rev; $V_{oil,2}$=28cm^3/h)

Frequency functions belonging to measurements are shown on Figures 6 and 7.

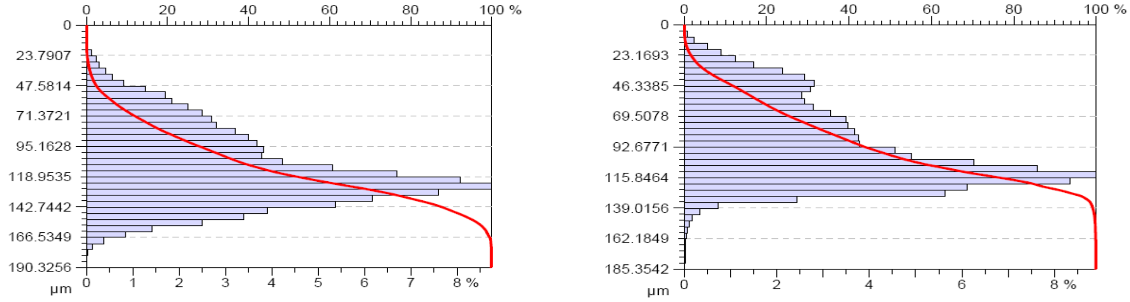


l =0 m
l =5 m

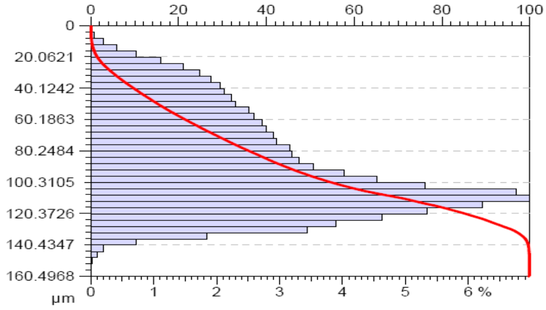


l =10 m

Figure 6 Frequency functions of 3D surface roughness measurement
(f_2=0.35 mm/rev; $V_{oil,1}$=0.0cm^3/h)



l =0 m
l =10 m



l =15 m

Figure 7. Frequency functions of 3D surface roughness measurement
(f_1=0.18 mm/rev; $V_{oil,2}$=28 cm^3/h)

Axial cross section of drilled specimen is illustrated on Figure 8.

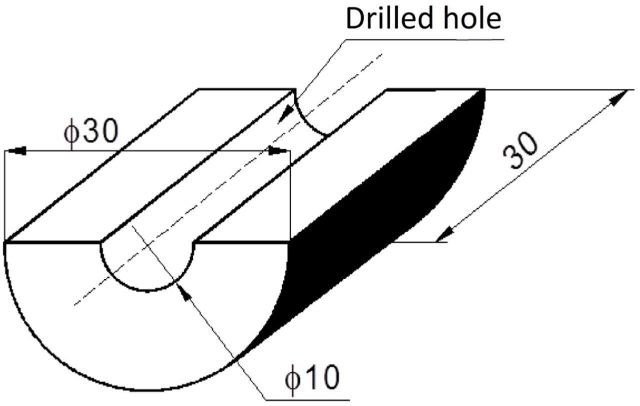


Figure 8. Main dimensions of specimen used to the experiments

3D surface roughness measurement technique usually applied for fine machined surfaces. Dry or minimal quantity lubrication (MQL) drilling does not belong to this group of machining. In spite of this we objected a 3D surface roughness analysis. Main results of measurements are described below.

For results of drilling with minimal lubrication (Fig. 5) a monotonic change can be observed by drilled length for surface roughness parameters (either increase of decrease). The case is different for dry drilling, (Fig. 4) where a maximum or a minimum occurs at medium drilled length (5m). Parameters of dry and minimal lubrication drilling are approximately equal in most cases, and if there is substantial difference, then dry drilling has more adverse value. For example geometric mean value of difference from centre plane (Sq) has maximal value 32,4μm, and 30,5μm for dry drilling. The situation is the same for algebraic mean value of difference from the central plane (Sa). For dry machining at drilled length 0-10m Sa=26,5μm, but for minimal lubrication machining Sa=25,8μm.

Frequency functions provide information about distribution of surface roughness data. Frequency function is quite skew in case of dry drilling, while it is closer to normal distribution for drilling with minimal lubrication. Maximum of curves are around 120μm for minimal lubrication in the range 0-15m of drilled length. This value is changing for dry drilling between 120μm and 147μm (Fig. 6).

Summary

Drilling experiments were performed with a set of different parameters. Surfaces of holes were investigated by 3D surface topology visualization technique, and standard surface parameters were calculated and evaluated. Main results can be summarized as follows:

☐ *3D surface roughness measurement machine and its data can be effectively applied for investigating surfaces created by less accurate cutting technologies.*
☐ *3D amplitude parameters are sensitive for technological parameters of cutting and volume of coolants and lubricants.*
☐ *Those parameters comparable with 2D surface roughness parameters are similar, but 3D measurements serve a more precise description.*

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REFERENCES

[1] I. KOLEV: Variations of technological costs and productivity when machining using multiple cutting tools, International Journal of Engineering, X. (2012) 2. pp 219-222. ISSN:1584-2665

[2] D. MATINSURESH BABU, M. SENTHIL KUMAR, J. VISHNUU: Optimization of cutting parameters for CNC turned parts using Taguchi's technique, International Journal of Engineering, X. (2012) 3. pp 493-496. ISSN:1584-2665

[3] A. SHOKRANI, V. DHOKIA, S.T. NEWMAN: Environmentally conscious machining of difficult-to-machine materials with regard to cutting fluids, International Journal of Machine Tools and Manufacture Vol. 57, June 2012, pp.: 83-101,

[4] DUDÁS, I., LIERATH, F., VARGA Gy.: Környezetbarát technológiák a gépgyártásban, Műszaki kiadó, Budapest, 2010, p.: 308

[5] ČEP, R., NESLUŠAN, M.; BARIŠIČ, B.: Chip Formation Analysis During Hard Turning, Strojarstvo, 2008, vol 50, No. 6, pp.: 337 - 345.

[6] KUNDRÁK, J., MAMALIS, A.G., GYÁNI, K., Et Al.: Environmentally friendly precision machining, Mater Manuf. Process 21 (1): 29-37 Jan 2006

[7] *SZIGETI F.-VARGA Gy.-DEZSŐ G.-PÉTER L.-SZÁZVAI A.: Forgácsolási paraméterek felületi érdességre gyakorolt hatása környezetkímélő megmunkálásoknál, MTÉAR (Műszaki Tudomány az Észak-Alföldi Régióban) 2010 konferencia, Nyíregyháza, 2010 Május 19. kiadvány, p.193-198. (ISBN 978-963-7064-24-1, ISBN 978-963-7064-23-4)*

[8] *F. SZIGETI, Gy. VARGA, G. DEZSŐ: Experimental investigation on roughness of drilled surfaces resulted from environmentally conscious machining, International Journal of Engineering, VIII. (2010) 3. pp.: 313-317. ISSN: 1584-2073*

[9] *M. MADIC, M. RADOVANOVIC: Application of CUCKOO search algorithm for surface roughness optimization in CO_2 laser cutting, International Journal of Engineering, IX. (2013) 1. pp.: 39-44. ISSN: 1584-2665*

[10] *STOUT, K.J., JIANG, X.Q. AND BLUNT, L.: Surface characterisation – its history and future, Proceedings of the Fourth International Symposium on Measurement Technology and Intelligent Instruments, Miskolc-Lillafüred, Hungary, September 2-4, 1998, 14-21.*

[11] *STOUT, K.J.: The three dimensions surface topography: measurement, interpretation and applications, Penton Press, London, 1994*

[12] *HORVÁTH, S.: A felületi hullámosság 2D-s és 3D-s jellemzése, a működési tulajdonságokra gyakorolt hatásának vizsgálata és elemzése, PhD értekezés, Zrínyi Miklós Nemzetvédelmi Egyetem, Budapest, 2008. p.117.*

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