

ТОПОГРАФИЯ НА КОНТАКТНАТА ТОЧКА ВЪРХУ ПОВЪРХНОСТИ ПОЛУЧЕНА ПРИ ХИДРОСТРУЙНО АБРАЗИВНО РЯЗАНЕ

ТОПОГРАФИЯ НА КОНТАКТНАТА ТОЧКА ВЪРХУ ПОВЪРХНОСТИ ПОЛУЧЕНА ПРИ ХИДРОСТРУЙНО АБРАЗИВНО РЯЗАНЕ

Sergej Hloch¹, Jan Valiček²

Faculty of manufacturing technologies, TU Košice with a seat in Prešov¹, Institute of Physics, Faculty of Mining and Geology, VŠB – TU Ostrava²

Abstract: The paper deals with detailed study of neglected zone situated on upper area of cut created by hydro-abrasive cutting. In order of detailed study was provided an experiments where was experimentally produced samples under various conditions defined by conditions for design of experiments. Surfaces on samples have been analyzed by non-contact commercial profilometer MicroProf FRT. Surface roughness of surfaces from stainless steel AISI 304 have been quantified by surface roughness profile parameters R_a , R_q and R_z which have been obtained by Gwyddion software from 27 depth traces. The results have been statistically evaluated. This presented work is a preliminary detailed study of neglected upper zones. Results obtained in the experimental part of the work, will serve as an important basis for further experimental research.

KEYWORDS: ENTRY ZONE, ABRASIVE WATERJET CUTTING, SURFACE TOPOGRAPHY

1. Introduction

Currently the mechanism of the hydro-abrasive jet cutting is not still understood as evidenced in new research reports of [1], [2], [9], [10], [11], [17]. The great lacks in that field are irregularities of the surface created by hydro-abrasive jet in neglected initial zone. The aim of our work is to carry out a comprehensive view of the surface topography in the initial zone created by hydro-abrasive cutting, classification of the shortcomings of classical (contact) the method of evaluation of the quality of the surface in the zone where the first contact with the material, confirmation of the existence of initial zone and their further study. The present work has been created in collaboration with company DRC Prešov, Ltd., where experimental samples were made. Measurements of surface profile parameters R_a , R_q and R_z has been made at Technical University of Brno.

2. Related and previous works

Surface topography created by AWJ of relatively thick material consists of a smooth upper zone and a striated, wavy lower zone (Fig. 1). Authors [3], [5] [11], [12], [14], [15] divide the surface, which is generated by AWJ on the mechanism of removal in the cutting mechanism and deformation mechanism.

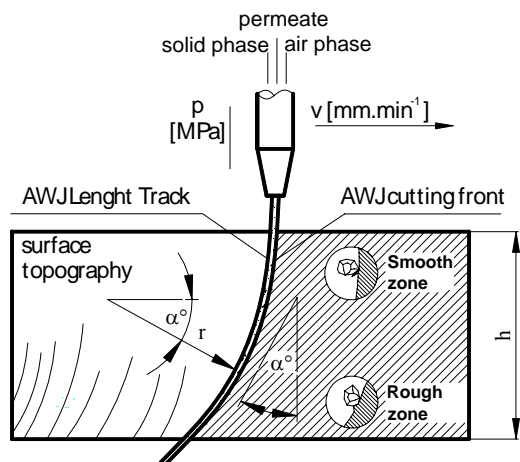


Fig. 1. Dependence of surface profile parameter R_a on depth of surface measured by means of contact and optical profilometer.

According research report published by [3] is a typical surface topography created by AWJ characteristic differences in horizontal bands. Authors [3] introduced the topography divided into three

areas: the initial zone, smooth and rough zone. The shape of the cut walls depends on the front spreading of WJ and AWJ from the upper to the lower side (Fig. 2). This is an image of the changes in the mechanism of disintegration. All the authors were concerned about the physical-mechanical aspects of the interaction of disintegration energy accumulated by the hydro-abrasive jet with the mechanical structure of the material. They divide these cutting walls into an upside qualitative smooth cut and the part of the cut deformation beginning from the critical depth (Fig. 1). Unevenness of the upper part of the cut is considered as microscopic, mostly unevenness at the roughness level. Unevenness in the lower part of the cut is already macroscopic with the presence of grooves and slots on the surface, mostly at the waviness level. According to preliminary our study by using the contact profilometer the initiation zone [4] with a rather great roughness could not be completely detected and localized.

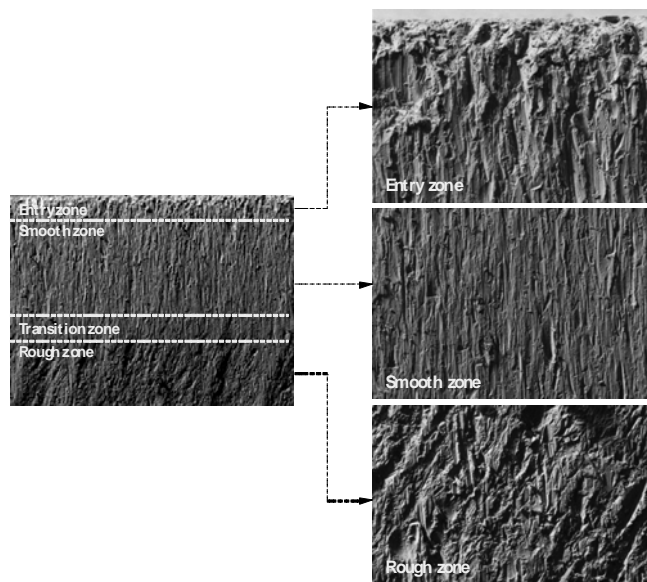


Fig. 2. Division of surface topography (material Ti-6Al-4V) [4].

On the contrary, results gained by an optical profilometer MicroProf (FRT), reported in studies by [13], [15], [16], show that more detailed information on the initiation zone can be provided. From the theoretical point of view, this entry region is of importance to the subsequent clarification of a mechanism of material removal and the explanation of AWJ-material interaction in this initiation zone. From the made analyses and from the obtained data on surface topography, a mechanism of formation of the surface topography, which is, as a matter of fact, a memory of

machining technology and also a witness to properties of the material machined, may be deduced. For the reason of mechanical flexibility, and thus the ability of AWJ tool to accommodate itself to material properties, this tool is very suitable for theoretical analyses. It is possible to say that in terms of newly developed science disciplines of technological inheritance, a profounder analysis of the process of surface layer origin can be carried out. Author [4] divide generated surfaces from the point of view of the removal mechanism into those with the removal mechanism of cutting character and those with the removal mechanism of deformation character. According to the literature [4], [7], the topography formed is divided into the initiation zone (which is, however, neglected by the majority of authors), the smooth zone and the rough zone (Fig. 2). In our opinion, in the framework of objectivity of the explanation of mechanism of origin of newly generated surface topography, the initiation zone cannot be ignored, because it evidences the first contact with a disintegration tool, which is here a high-energy jet of the mixture of water, air and abrasive. Whenever two machined surfaces come in contact with AWJ tool another the quality of the mating parts plays an important role in the performance and wear of the machined parts.

3. Experimental set up

Roughness profile parameters Ra , Rq and Rz determined by means of optical profilometer MicroProf FRT from manufacturer Fries Research & Technology GmbH, Germany, on a workplace of Physical engineering institute FSI VUT in Brno [15], [16]. By three-dimensional contactless and non-destructive measurement was obtained matrix value of altitude unevenness of surface, generated by composition of AWJ technology factors from the entry zone area of the surface. In the area of AWJ entry, for the purpose of identification and analysis of factors influence on topography of surface to detect an initial zone, was the value of equidistant distances of particular depth traces from the surface 0.1 mm from to 2,5 mm. In all measurements were realized in 27 depth traces. Proper measurements were realized in the central zone of the sample excluding marginal areas of the sample to reach the most accurate measurements. Each measurement was repeated 8 times to reach statistically the most accurate result.

4. Results and discussion

On the surfaces samples made from aluminium can be clearly distinguished entrance area, the cut surface and exit area. Created surfaces and associated irregularities show the specific geometry, as they are produced by different technological conditions [12]. This zone occurs by degradation of abrasive waterjet on surface area exposed samples with increasing depth, with the first contact the abrasive jet with target material. Limit the initiation zone can be determined by the measured values of Ra , Rq and Rz (Fig. 4). Incidence of initiation zone is characterized by a sharp increase of Ra , Rq , Rz (Fig. 4). After overcoming the total resistance of the material in the initiation zone we see a sharp decline in the Ra , Rq , Rz , which is caused by the resistance of the material transmitted by abrasive waterjet. On Fig. 4 depicts the course of the numerical values of Ra , Rq and Rz 27-deep traces with marked initiating zone (Fig. 3). Characteristic surfaces in initiating this zone are to be found in the technology that formed the mechanical effect of operating abrasive waterjet. According to some authors, not in terms of objectivity explanations creation mechanism does not surface with the initiating zone, because in terms of first contact with AWJ, the characteristics are not influenced by material that was removed from the wall of machined material. Limits of initiation zone located in the entrance area are the small features rounded edges on the surface due to plastic deformation of material. The graphs below show the detail that at the beginning of initiating zone are increased the profile roughness parameters Ra , Rq , and Rz . High values of roughness parameters Ra , Rq and Rz

causing bridging modulus of elasticity of material and thus its total resistance material. After overcoming the decline occurs figures surface roughness profile parameters Ra , Rq and Rz (Fig. 4a, b). After reaching a critical limit, thus overcoming initiation zone, which has not been quantified it is already part of abrasive waterjet collected material from the cutting material. There is a surfeit AWJ structure and its inner core of a slowdown compared with AWJ. Peripheral part of AWJ at this stage contains a high concentration of grains, which accumulate in the depths of the result of a slowdown. Due to the local crowding is a relatively smooth surface creates a trace of where they were recorded a low profile, the numerical values of roughness parameters Ra , Rq and Rz . In terms of factor analysis, it can be concluded that the width of the zone influenced by initiating a specific combination of factors. This means that the occurrence of the border separating the smooth from the initial zone and setting its width depends on the hydrodynamic properties of the instrument, technological factors and material properties (Fig. 4a, 4b).

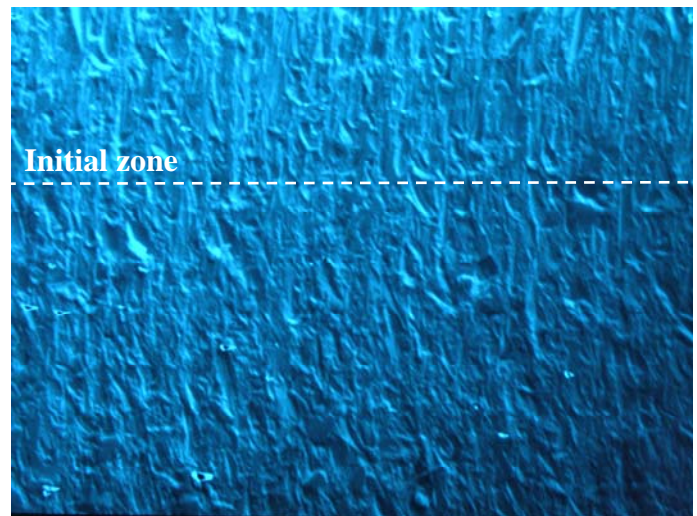


Fig. 3. SEM photographs of entry area obtained, magnification 50x (material aluminium).

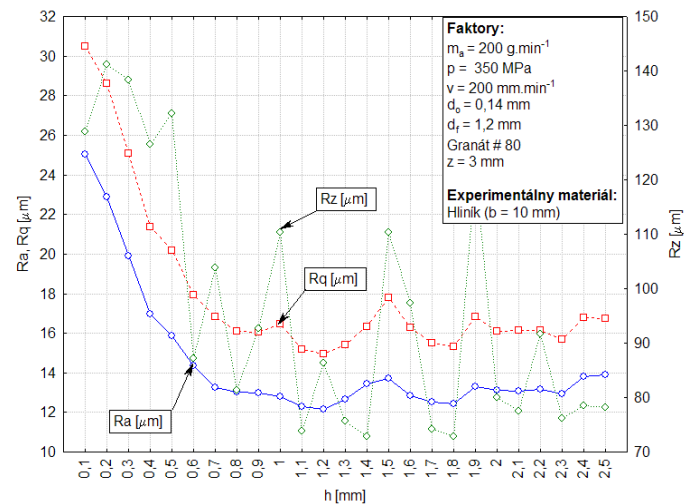


Fig. 4. Behaviour of surface roughness profile parameters Ra , Rq and Rz in entry zone of the surface (0,1 – 2,5 mm).

5. Conclusions

Till today in scientific circles, and technical practice persist opinion that with the depth of cut, the higher the numerical values of parameters Ra , Rq and Rz grows. This finding was due to the fact that in determining the parameters of roughness profile of the individual measurements are carried out contact profilometers, which do not permit a detailed analysis of the entry surface area

created abrasive waterjet. Made measurements and their detailed analysis, however the predominant view corrects. The present work points to the absence of a deeper analysis of the topography in the entrance area of the surface where there is initiating zone. For that reason is given a systematic overview of the technology division AWJ, in terms of testing technology necessary to analyze in detail. The knowledge gained will help more effective and easier to fix the quality for the forthcoming technological practice. It should be noted that even if there is a functional surface, this zone may have in the future great importance in terms of diagnosis of the immediate state of technology and technological process. Its importance lies in the fact that this part of the surface characteristics may be directly detectable and may be examined by the current state of the quality of the surface prepared for the purpose of automation of technological process and its AWJ continuous quality control process of disintegration of the material.

Acknowledgment

The authors would like to acknowledge the support of Scientific Grant Agency of the Ministry of Education of Slovak Republic, Commission of mechanical engineering, metallurgy and material engineering, for their contribution to project VEGA 1/4157/07 Non linear mathematical modelling and the vibro diagnostics of progressive technological processes at separation of hard workable materials by means of DoE a Taguch design and projects MŠMT č.MSM6198910016, GA ČR 101/09/0650.

6. References

- [1] Akkurt, A, Kulekci, M.,K, Seker, U., Ercan F. Effect of feed rate on surface roughness in abrasive waterjet applications. *J Mater Process Technol* 2004;147:389–96.
- [2] Barry, J., Byrne, G., Lennon, D. Observations on chip formation and acoustic emission in machining Ti–6Al–4V alloy. In: *International Journal of Machine Tools and Manufacture* 2001;41:2245–60.
- [3] Chen, F., L.; Siores, E. The effect of cutting jet variation on striation formation in abrasive water jet cutting, In: *International Journal of Machine Tools & Manufacture* 41 (2001) 1479–1486.
- [4] Hascalik, A., Caydas, U., Gurun, H. Effect of traverse speed on abrasive waterjet machining of Ti–6Al–4V alloy. In: *Materials & Design*, Volume 28, Issue 6, 2007, pp. 1953-1957
- [5] Hashish, M. Optimization factors in abrasive waterjet machining. *ASME J Eng Ind* 1991;113:9–37.
- [6] Hlaváč, L., M. et al. Quality Investigation by Declination Angle of the Water Jet Trajectory Inside Kerf. In: *Proceedings of Technology Systems Operation* (Hloch, S., et al. Ed.), Prešov 2007, pp. 15-18.
- [7] Hloch, S., Gombár, M., Valiček, J. Analysis of abrasive waterjet factors influencing the cast aluminium surface roughness. In: *International Journal of Precision Technology*. vol. 1, 2007, pp 1-10.
- [8] Jegaraj, J., J., R., Babu, R., N. A strategy for efficient and quality cutting of materials with abrasive waterjets considering the variation in orifice and focusing nozzle diameter. In: *International Journal of Machine Tools & Manufacture*, vol. 45, (2005), pp. 1443-1450.
- [9] Kulekci, K., M. Processes and apparatus developments in industrial waterjet applications. *International Journal of Machine Tools & Manufacture* 42 (2002) 1297–1306.
- [10] Martinec, P., Foldyna, J., Sitek, L., Ščučka, J., Vašek, J. *Abrasives for AWJ cutting*. 2002, Academy of Sciences, Czech Republic. p. 80.
- [11] Momber, W., A., Kovacevic, R. *Principles of Abrasive Water Jet Machining*. Springer-Verlag Berlin Heidelberg, 1998, New York.
- [12] Monno, M., Ravasio, C. The effect of cutting head vibrations on the surfaces generated by waterjet cutting. In: *International Journal of Machine Tools & Manufacture*, in 45 (2005), pp. 355-363.
- [13] Páleníková, K., Ohlídal, M. Potentialities of optical profilometer MicroProf FRT for surface quality measurement, 14 th Slovak-Czech Polish Conference on Wave and Quantum Aspects of Contemporary Optics, pp. 594510-1-59456, ISBN 0-8194-5951-8, (2005), SPIE - The international Society for Optical Engineering.
- [14] Guo, N., S., Louis, G., Meier, G. Surface structure and kerf geometry in abrasive waterjet cutting: formation and optimization. In: *Proceedings of the seventh American waterjet conference*, Seattle (WA, USA); 1993.
- [15] Ohlídal, M. The Scattering of Light from Rough Surfaces and Its Application in Surface Roughness Measurement. In: *Proceedings of Technology Systems Operation* (Hloch, S., et al. Ed.), Prešov 2007, pp.35-39. ISBN 978-80-8073-900-3.
- [16] Páleníková, K., et al. Topography analysis of metallic surfaces generated by abrasive waterjet. In: *TSO - Technology Systems Operation 2007 : 8th international scientific conference: Proceedings : 21st-23rd November 2007*, Prešov. Prešov : FVT TU, 2007. s. 236-239. ISBN 978-80-8073-900-3.
- [17] Sitek, L., Foldyna, J., Švehla, B. Vodní paprsek ve strojírenství. *Strojárstvo*, 2004A, roč. 8, č. 5, s. 100-101. ISSN 1335-2938.