S. HLOCH, J. VALÍČEK, I. SAMARDŽIĆ, D. KOZAK, M. KUŠNEROVÁ

ISSN 0543-5846
METABK 51(1) 125-128 (2012)
UDC – UDK 621.96:621.7:620.1.001.3=111

CLASSIFICATION OF TECHNICAL MATERIALS ACCORDING TO CLASSES MACHINABILITY FOR HYDROABRASIVE CUTTING

Received – Prispjelo: 2011-01-28
Accepted – Prihvaćeno: 2011-04-18
Review Paper – Pregledni rad

This paper presents the major cutting knowledge, the opinion data and the results of actual theoretic parameters solutions and the current results, estimated by contemporary needs of hydro abrasive cutting technology. Here is a newly opened and discussed question of current data terminology disunity in the area of metrology topography surfaces of cutting walls created by abrasive waterjet.

Key words: hydroabrasive cutting, machinability, divisibility, classification categories of materials

Klasifikacija tehničkih materijala prema klasama obradivosti kod hidroabrazivnog rezanja. U radu su prezentirana temeljna znanja, razmišljanja i rezultati teorijskih rješenja vezano uz trenutne procijenjene suvremene potrebe za hidroabrazivnom tehnologijom rezanja. Ovdje je i ponovo otvoreno pitanje trenutne terminologije u području mjeriteljstva topografije površina dobivenih rezanjem abrazivnim vodenim mlazom.

Ključne riječi: hidroabrazivno rezanje, obradivost, djeljivost, klasifikacijske kategorije materijala

INTRODUCTION

At the present time, requirements on increase of cutting materials production by high strongholds and hardness (e.g. titanium, nickel, composite materials, etc.) continuously grow. Conventional methods of cutting are not always technically and economically acceptable for cutting these materials, therefore new so - called „unconventional" cutting methods get more popular. These unconventional methods of cutting are implemented particularly when classical methods are less effective, or when they totally fail. They benefit all sorts of physical principles how to shape material (e.g. chemical, electrochemical, mechanical, etc.). One of these unconventional methods is also abrasive waterjet cutting (AWJ), especially high - speed liquid jet with additive of strong abrasive materials. The high speed of flowing out waters with additive of abrasive makes it possible to shape intensively, economically and at the same time ecologically wide spectrum of industrial materials from paper, paste - board, wood, plastic, cork, building matters and rocks to metals and their alloys. These are highly actual technologies due to its universality, environmental economy and safety within machining industry. While the technology of a proper cutting by AWJ is already hardware also software based, except specific cases, there is still a technical issue with the way of a quality verification of a machined surface of continual drive at production.

S. Hloch, J. Valíček, M. Kušnerová, Faculty of Manufacturing Technologies TU Košice with a seat in Prešovi, Slovakia, I. Samardžić, D. Kozak, Mechanical Engineering Faculty J. J. Strossmayer University of Osijek, Slavonski Brod, Croatia

RELATED WORKS

The cutting process of technology AWJ is the hydroabrasive disintegrative process caused by the strength, the tension and the deformation effect of cutting tools on work material. The tool is the high - speed flow of water and the abrasive mixture. The result of the process cutting is the dividing cut. The mechanism of outer and inner reactionary physical- mechanical factors is developed by cutting tool that reaches the balance. This balance is displayed by the three-dimensional topographical function of surface state of cutting walls generated in the cutting level. It is dividing or a cutting tool with somewhat different mechanical features, than are dividing, cutting, shaping or drilling tools in classical engineering or other spheres. This cutting tool is flexible not solid, therefore the trajectory of its dividing cutting trace changes quickly in critical moments of interaction with material. The abrasive deformation process of AWJ stream is in principle given by the elemental action of abrasive particles. The principle of the strength effect is in impact speed at contact with surface of cutting front in level of the contact angle. It is about the interaction between the effective AWJ stream field and instantaneously geometric proportions of surface interactive stressed spot of material in the cutting level by the AWJ stream field. The reversed reaction of material causes changes in the process of cutting, changes original material parameters and initial parameters change AWJ stream field. The cutting of material by AWJ technology is specified by a typical curvature and delay of cut trace behind nozzle at its deepening. The physical mechanical and strain-tension characteristics of material of workpiece determine the intensity of reactionary forces and characterize, or sort every material to the group of its hydroabrasive divisibility by AWJ stream. To date a general opinion dominates about the physical- mechanical complication of the cutting process also its analytical solution, i. e. about complication of a definite physical - mathematical description in its simultaneous functions regarding segmentation of the whole set of technical, technological and material parameters that enter the process. Procedural functions of these parameters are mutually blended and they influence each other. At the same time their partial effects may developed or interfere on the contrary. Apart from that value of the parameters are not constant, but change in different ways in time. From analytical point of view a generally accepted opinion dominates about complicacy of analytical solution and especially such solution that would be simply and effectively applicable in practice. This opinion confirms to date the reality of the insufficient theoretic mastered of cutting disintegration mechanism of material by the forces abrasive effect.

PROBLEM DEFINITION

On the basis of historical study and contemporary development of the technology AWJ in theory, experiments and practice we know, agreeable with opinion contemporary authors [1-19], that the problems of the physical- mechanical disintegration materials principle and production of new surface by hydroabrasive cutting stays also today live that is why till this time open. According to mechanical properties of divided material it happens only to shift in - depth levels of these zone characterized by identical elements of a topography surface. Identical values of ratios introduced of geometric quantities correspond then identical values zoned distributed of mechanical and strain-tension quantities.

If it is necessary to study these patterns to disposal the samples that are high e.g. only 8 mm for all investigate materials, it is impossible in a simple way to compare the results of measurement, because at soft materials all over high sample moved in the elastic zone of loading, but on the contrary at solid material it is already moved e.g. from 4 mm depths in the plastic zone. The in-depth limits of transition from the elastic to the plastic zone is e.g . for solid Cor-Ten steel CSN 13 242 with modulus flexibility in traction $E_{\text{stalemate}}$ = 220 GPa naked 5,4 mm, while for clean aluminium Al with modulus flexibility E = 72 GPa result from this limits by prediction calculation as far as on 52,1 mm depths of cut. It is possible to find on these zonal levels then identical conditions for both materials among geometric also strain-tension parameters. The in-depth position of transition from the elastic to the plastic zones is nevertheless influenced in given material domineering by choice of technological parameters of support:

1. analytical encompassment of patterns of values zonal distribution of geometric and strain-tension parameters is a condition for prediction of computational equations, that are important in final consequence not only for choice of technology, but also for automated control of the shaping process. The reasons to simultaneous data generally confessing insufficient level present of knowledge it is possible in fine frame to the next points: inadequate respect of the material physical- mechanical parameters of samples with their uniform of mathematical formulation absence,
2. inadequate respect of the physical- mechanical parameters of AWJ stream as cutting tool with uniform of mathematical description absence,
3. inadequate respect of the physical - mechanical, respective system tension-deformation integrity: the technological parameters - the tool - the material - the topography of surface,
4. insufficient exploitation – of patterns study of distribution and the zonality geometric parameters of surface by a hydroabrasive process of generated cutting walls,
5. the absence of enough generalized theoretic prediction limit reached depths in different materials,
6. the total factionalism of results from different experimental workplaces and thereby given to their bad mutual correlate,
7. the low level of results generalization reached on different workplaces,
8. till this time it is not to elaborate some uniform nomenclature of technological and metrology conceptions,
9. serious absence is the absence of uniform material technological classification according to their divisibility of hydroabrasive technology.

MATERIAL MACHINABILITY

At solution of material deformability and instantaneous state of the cutting wall in cut on principle it is possible to go out from the integrity of system: the technological parameters - the tool - the material - the surface topography and from determine parameters of geometric elements, that are measurable on surface of final wall of dividing cut.

In dividing cuts realized by hydroabrasive tool the loading and disintegration conditions are essentially different comparing to the stress on material in laboratory conditions. Laboratory and analytical investigation and description of a deformational process in dividing, or cutting trace, or slot requires development and utilization specific progress. The principle is a deduction and formulation of technological and mechanical parameters of materials, which are physically what tightly fixed to specification of desintegrative mechanism of the process itself. Subsequently then to analytically disclose and describe patterns by which physical - mechanical alterations of these parameters are adhered whether by deepening of hydroabrasive cut, or by changes of some of the main technological parameters.

While laboratory measurement of basic mechanical and also technological parameters of technical materials is provided in line with strict norms in order to match results and reproducibility, the normative for an AWJ technology is likewise late. Therefore it is possible only with difficulties though to compare and generalize the results published by various laboratories. For personal experimentation it is therefore necessary to choose a referential technology, namely for hydroabrasive dividing, as well as for measurement and evaluation of surface geometry dividing walls. In order to statistically analyse likewise resulting values to deposit and process in the form of data bank data [18], there has not yet been provided any technological classification of technical materials by categories of divisibility by hydroabrasive tool and thus it is still a serious issue. Therefore within this study, it can be suggested, the technological classification of materials to the divisibility categories T_{cut}, whereas T_{cut} is decimal logarithm of Young's modulus of material flexibility. Numeric value of hydroabrasive machine ability $T_{cut} = \log (E_{mat})$ divides whole spectrum of technical materials on T_{cut} 1 – T_{cut} 6 classificatory class. The hydroabrasive divisibility is therefore likely to be defined as technological nature of a material expressing a level of its resistance against desintegrative forces generated in cut by high - speed streaming of AWJ according to decade logarithm modulus of flexibility material in traction E_{mat} (Figure 1). The materials with biggest resistance against abrasive cutting forces developed by a stream of AWJ are classified within categories T_{cut} 5,5 as far as T_{cut} 6 (diamond, technical ceramics, sailcloth). By contrast materials with the smallest resistance are classified within the classes T_{cut} 1 as far as T_{cut} 2 (elastomers, polymers, cork). Because of extremely high values of modulus flexibility, strongholds and hardness of materials from the class T_{cut} 5,5 to T_{cut} 6, it is possible to talk about divisibility of these materials by the help of AWJ only theoretically, because their mechanical parameters already exceed the values by mechanical parameters of industrial abrasive used nowadays. Garnet and olivine are ranged at the level of steel to the categories from T_{cut} 5 to T_{cut} 5,5. Classification chart on figure 1 is useful for schematic view of sorting the materials into groups to the divisibility categories. For a practical use by a technologist it is possible to provide a detailed classification of technical materials in a table format, whereas every category in the table can classify other technological properties, which are important and characteristic for the specific category considering a projection.

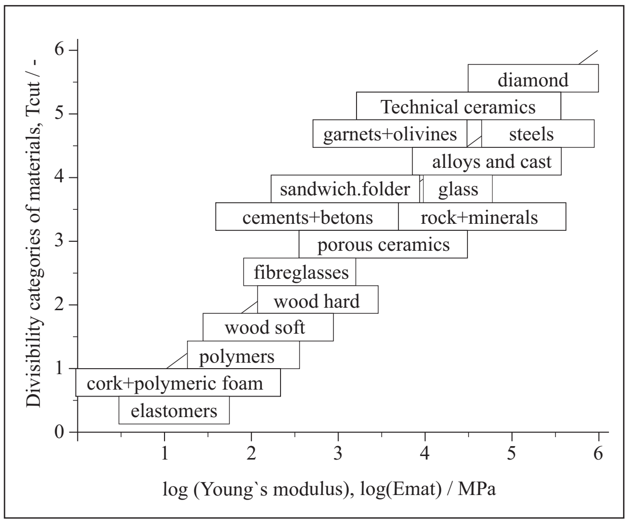

Figure 1 Distribution of technical materials to the divisibility categories T_{cut}.

CONCLUSIONS

In this study there were analysed piece of knowledge about production of a dividing cut, opinion data and results of present theoretic solution parameters of cut to the critical estimation of current levels of results from the contemporary needs of hydroabrasive dividing technology point of view. A question of current data terminology division in the area of metrology of surfaces topography cutting walls created by abrasive water jet is discussed here as well. Proposing a category of materials divisibility is a very important technological indicator. A definition of classification categories T_{cut} is based on the relation to the one of the most important mechanical parameters of materials of Young's modulus flexibility E_{mat}, therefore the classification material class is functionally fixed to the values of cutting resistances, cutting speed and to characteristics of reduction. Classification of technical materials in line with categories of hydroabrasive divisibility T_{cut} has therefore a great meaning practically for the first orientation of the technologist within choosing the main technological parameters of working regime.

REFERENCES

[1] Hashish, M.: Modeling Study of Metal Cutting with Abrasive Waterjets. Trans. of the ASME, Journal of Eng. Mat&Tech, 106(1984)1, 88-100

[2] Hashish, M.: Pressure Effect in Abrasive – Waterjet (AWJ) Machining. Trans. of the ASME, Journal of Eng. Mat&Tech., 111(1989)7, 221-228

[3] Guo, N. S.: Schneidprozess und Schnittqualität beim Wasserabrasiusstrahl – schneiden. VDI Verlag, 1994

[4] Zeng, J., Kim, T. J.: A study of brittle erosion mechanism appleid to abrasive waterjet processes. Proc. 10th Int. Symp. on Jet Cutting Technology, BHRA, England, 1990

[5] Vašek, J., Martinec, P., Foldyna, J., Sitek, L., Ščučka,J.: Abrasives for AWJ cutting. Academy of Sciences, Ostrava, 2002

[6] Blickwedel, H., Guo, N.S., Haferkamp, H., Louis, H.: Prediction of abrasive jet cutting ffeciency and quality. Proc. 10th Int. Symp. on Jet Cutting Technology, BHRA, Fluid Engineering Centre, Cranfield, UK, 1990

[7] Lebar, A., Junkar, M. Surface evaluation methods for advanced AWJ cutting techniques. In. Manufacturing systems (Aachen), 31(2001)2, 101-103.

[8] Brandt, S., Maros, Z., Monno, M.: AWJ parameters selection – a technical and economical evaluation. Jetting Technology, BHR Group, 2000

[9] Burnham, C. D., Kim, T. J.: Statistical characterization of surface finish produced by a high pressure abrasive waterjet. Proc. 5th American Water Jet Conference, Toronto, Canada, 1989

[10] Singh, J.P., Khen, W.L., Munoz, J.: Comprehensive Evaluation, of Abrasive Waterjet Cut Surface Quality. Proc. 6th American Water Jet Conference, Houston, Texas, WTJA, 1991

[11] Agus, M., Bortolussi, A., Careddu, N., Ciccu, R., Grosso, B.: Optimization of abrasive – workpiece machinig. Jetting Technology, BHR Group, 2000

[12] Yong, Z., Kovacevic, R.: Modeling of 3D abrasive waterjet machining part 4 - simulation of machining. Jetting technology, BHR Group, 1996

[13] Barenbrock, D., Louis, H., Tschimmel, J.: Novel three – dimensional parameters for description of modifications of sheet metal surfaces during forming processes. ICM88, Victoria, Canada, May 1999

[14] Valíček, J., Hloch, S., Držík, M., Ohlídal, M., Mádr, V., Lupták, M., Radvanská, A.: An investigation of surfaces generated by abrasive waterjet using optical detection. In. Strojniški vestnik - Journal of Mechanical Engineering. 0039-2480: 53, 2007. 224 - 323. ISSN 0039-2480.

[15] Valíček J, Hloch S. Optical measurement of surface and topographical parameters investigation created by abrasive waterjet. In: International Journal of Surface Science and Engineering. 3(2009)4, 360-373.

[16] Valíček J, Hloch S. Using the acoustic sound pressure level for quality prediction of surfaces created by abrasive waterjet. In: The International Journal of Advanced Manufacturing Technology. 48(2010)1-4, 193-203.

[17] Valíček J, Hloch S, Kozak D. Surface geometric parameters proposal for the advanced control of abrasive waterjet technology. In: The International Journal of Advanced Manufacturing Technology. 41(2009)3-4, 323-328.

[18] Hloch S et al. Experimental study of surface topography created by abrasive waterjet cutting. In: Strojarstvo. 49(2008)4, 303-309.

[19] Hloch S., Valíček J., Simkulet, V. Estimation of the smooth zone maximal depth at surfaces created by Abrasive Waterjet. International Journal of Surface Science and Engineering. 3(2009)4, 347 - 359.

Acknowledgements

The work has been supported by projects GA ČR No. 101/09/0650, SGS No. SP/2011/78, MŠMT No. MSM6198910016,RMTVCNo.CZ.1.05/2.1.00/01.0040. Thanks also to the Moravian-Silesian Region for financial support and VEGA 1/0972/11.

Note: Responsible translator: Željka Rosandić, Faculty of Mechanical Engineering in Slavonski Brod, University of Osijek, Slavonski Brod, Croatia