Application of Nanometrology for Assessing the Machining Tool Geometry and Analysis of the Micro/Nano-Structure of the End Milling Tool Surfaces

[1]G. Bas, [1]N.M. Durakbasa, [2]I. Mankova, [2]J. Beno

[1]Vienna University of Technology, Dept. of Interchangeable Manufacturing and Industrial Metrology, Karlsplatz 13/3113, A-1040 Vienna, Austria
[2]Technical University of Kosice, Mäsiarska 74, Kosice, Slovakia
Email: numan.durakbasa@tuwien.ac.at

Abstract. *Nanotechnology is an interdisciplinary field developing for the global markets in all sectors depending strongly on the nanometrology science for quality, health and environment, safety, efficiency and verification of legalized standards and certificates. Therefore, the machining industry in requirement of higher customer and market demands in the global market, needs to integrate the nanometrological process into their structure. Taking this requirement into consideration, in this study the coating nanotechnology applied on cutting tools are observed and compared with the noncoated tools in terms of micro- and macrocharacteristics. The nanometrological process was modeled and carried out using both optical digital microscope and contact mode profilograph as a step to establish a database for a market analysis in the future.*

Keywords: Measurement, Nanometrology, Quality, Cutting Tool

1. Introduction

The development of nanotechnology applications in the machining industry have been indispensible in order to operate competitively in the market[1]. The nanotechnology applications by effective nanomultilayer coating, surface profile and roughness values, micro- and macrocharacteristics are the major influences that affect the cutting tool high precision operation lifetime, the process quality and the industrial requirements compatible with the standards [2]. Together with the nanometrological process integrated in assessment of the nanotechnological improved cutting tools, this study proposes an integrated approach to enhance the operations of the tool and machining industry.

There has been much prior research conducted to improve fatigue strength, corrosion resistance, tool lifetime and that will eventuate in a major influence for the economical and environmental performance of the cutting tools. The major influence of the surface roughness and cutting edge coating has been investigated so far by means of diverse numerical modeling [3-4]. However, the characterization of the micro- and nanocharacteristics of the cutting edge of the end cutting tools is often challenging due to the experimental precision measurements. In this study, the surface roughness characterization process was carried out by nanometrology devices in order to overcome the challenges by predefined limits in compliant with the international standards.

2. A Strategic Approach to Assess the Cutting Tools in the Machining Industry

The experimental tool life determination for real applications of the machine industry is more complex than its suggested mathematical models. The ISO Standard 8688 guides us on the deterioration of tools due to the tool wear [5]. However the end milling tool deterioration must be investigated as a total effect of wear, edge fracture and deformation. Therefore the end milling cutting tool lifetimes are assessed based on the cutting time and process variables

using the response surfaces. The mathematical model of a tool lifetime under constant depth of cut (mm) and feed rate (mm/tooth) using the Taylor's model is as follow [6]:

$$V.\,Tn = C$$

where V : cutting speed (m/min)
T : predicted tool lifetime (min)
C, n : constants (process and material)

For determination of constants in the mathematical model, a logarithmic transformation must be performed. The quality of machining with the end milling tools is affected with the process constants and surface parameters. Due to the importance of the process parameters and the surface characterization, a strategic approach is introduced as a process management model as presented in the Fig. 1 [7].

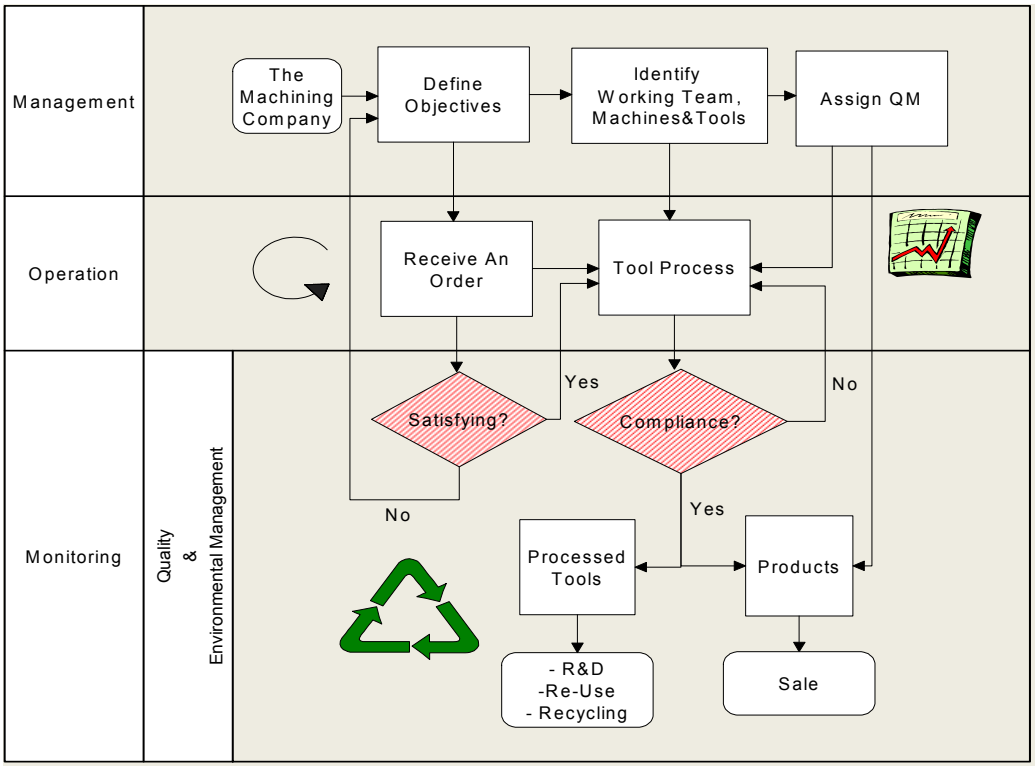

Fig. 1. A Proposal to the Strategical Process Management in Machining Industry

3. Assessment of the Cutting Tools

In this study, surface quality of cutting edges of the selected high precise cylindrical cutting tools was investigated in micro and nano scale. The analyses of the surfaces of the cutting tools were performed for PVD AlTiN coated end mills. The surface investigations consist of the non-contact mode optical capturing of the magnified images by CCD camera of the 3D digital microscope (DM) and a tactile stylus-type surface profilometer for high precise and accurate measurement results compliant with the standards [8, 9, 10].

The capturing results of the magnified surface images measuring the 2D and 3D micro and nanogeometry of the cutting edge (Fig. 2) by the optical digital microscope [11].

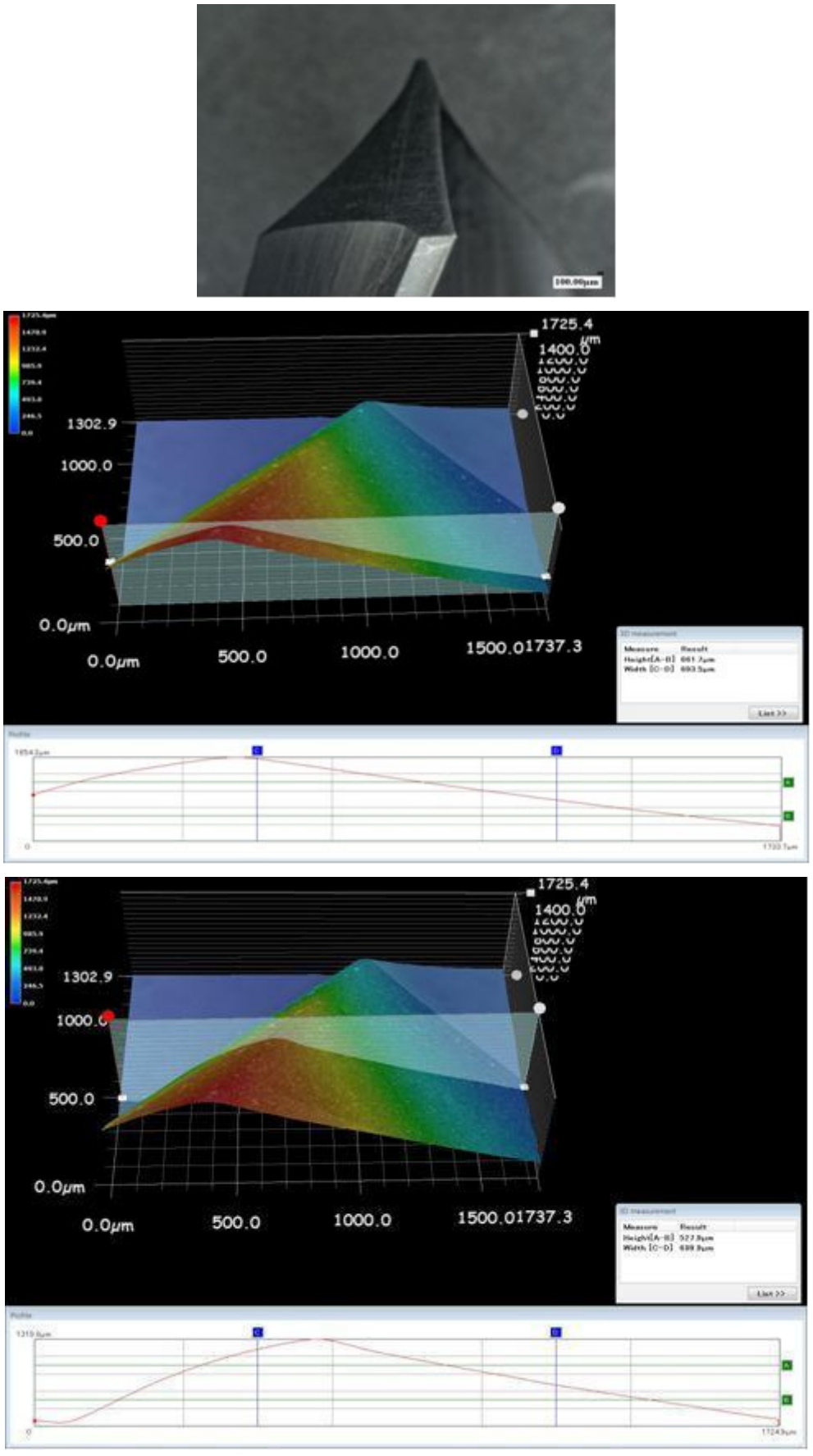

Fig. 2. The micro- and nanogemoetry measurement of the end milling cutting edge using the digital microscope

4. Conclusions

The nanotechnological developments to be applicable on the coatings, surface profile, micro and macrocharacteristics of the cutting tools in order to increase tool lifetime, precision and quality are vital to maintain a competitive operation in today's machining industry. In this study, a startegical nanometrological process is proposed to integrate into the machining industry for assessing the high precision cutting tools compliant with the international standards and measurements are carried out to examine the cutting tools in both 2D and 3D metrological investigations. The micro and nano scale measurements have been stored in order to creative both qualitative and quantitavie data on edge cross-sections that is known to be the most fluential region for quality and life-time of the machining tools.

Acknowledgement

This work was supported by the bilateral project " Wissenschaftlich-Technisches Abkommen mit der Slowakei 2013-14" with the Project Number SK 04/2013 and the title "Implementierung von Nanometrologie Prozessmanagementmodell für die Beurteilung der Werkzeugschneidkanten in der Präzisionsbearbeitung - Implementation of nanometrological process management model into cutting tool edge assessment in precision machining".

References

[1] European Union, Coordination of Nanometrology in Europe (Co-Nanomet) Seventh Framework Programme: *European Nanometrology 2020*. 2009.

[2] Durakbasa M.N., Bas G., Demircioglu P.: A Nanometrological Process Management Model to Assess the End Milling Tools in the Machining Industry. 13th International Conference on Tools, March 2012, Miskolc, Hungary.

[3] Miani F., Guseo R., Mortarino C.: A new Proposal for Tool Life Analysis Response Surface Modelling of the Flank Wear Progression, II International Seminar on Improving Machine Tool Performance Proceedings, 3-5.July, 2000.

[4] Kundrak J.,Raczkövi L.: Definition of Tool Life in hard Boring, Proc. of the International Scientific Conference XXV.microCAD, Section L: Production Engineering and Manufacturing Systems, 2011, pp. 99-104.

[5] ISO International Organization for Standardization: ISO 8688-2 Tool Life Testing in Milling - Part2: End Milling, 1989.

[6] Hung N.P., Boey F.Y.C., Khor K.A., Phua Y.S., Lee H.F.: Machinability of Aluminum Alloys Reinforced with Silicon Carbide Particulates, Journal of Materials Processing Technology 56 (1996), pp. 966-977.

[7] ISO 9001:2008 Quality Management Systems – Requirements.

[8] ISO 4287:1997/prA2:2013 Geometrical Product Specification (GPS)- Surface texture: Profile method - Terms, definitions and surface texture parameters.

[9] DIN EN ISO 25178-6:2010 Geometrical product specifications (GPS)- Surface texture: Areal - Part 6: Classification of methods for measuring surface texture.

[10] ISO 25178-601:2010 Geometrical product specifications (GPS)- Surface texture: Areal – Part 601: Nominal characteristics of contact (stylus) instruments.

[11] EN ISO 4288:1998-04, Geometrical Product Specifications (GPS)- Surface texture: Profile method - Rules and procedures for the assessment of surface texture.