machines

Editorial

Advances and Trends in Non-Conventional, Abrasive and Precision Machining

Mariusz Deja [1,*] and Angelos P. Markopoulos [2]

[1] Department of Manufacturing and Production Engineering, Faculty of Mechanical Engineering and Ship Technology, Institute of Machine and Materials Technology, Gdańsk University of Technology, 80-233 Gdańsk, Poland
[2] Laboratory of Manufacturing Technology, School of Mechanical Engineering, National Technical University of Athens, 157 73 Zografou, Greece; amark@mail.ntua.gr
* Correspondence: mariusz.deja@pg.edu.pl

check for updates

Citation: Deja, M.; Markopoulos, A.P. Advances and Trends in Non-Conventional, Abrasive and Precision Machining. *Machines* **2021**, *9*, 37. https://doi.org/10.3390/machines9020037

Received: 3 February 2021
Accepted: 5 February 2021
Published: 8 February 2021

The modern, highly competitive industrial environment demands machining and production processes that result in exceptional quality and precision. The general trend of design and manufacturing more complicated mechanical components, along with the rapid development of material science, raise the need to incorporate and develop new machining techniques in the manufacturing process. Nonconventional machining processes differ from conventional ones, as they utilize alternative types of energy, such as thermal, electrical, and chemical, to form or remove material. Usually, the energy source has a high-power density, while the process must be extremely accurate and able to produce and handle demanding shapes and geometries. Examples of nonconventional machining processes are electrical discharge machining (EDM), electrochemical machining (ECM), laser processing, and laser-assisted machining. Abrasive processes like grinding, lapping, honing, polishing, and superfinishing are constantly developing, and help to obtain a fine surface finish along with high efficiency. There is an increased scientific and commercial interest in in-depth understanding and further development of the aforementioned nonconventional and precision machining processes. Research is moving forward through experimental studies, as well in the field of modeling and simulation, exploiting the increased available computational power. Multiphysics, multidisciplinary and multiscale modeling are powerful tools in the effort to optimize existing nonconventional precision machining processes, as well to develop novel ones. As their wider use by the industry swiftly grows, research has to be focused on them, not only due to their academic and scientific interest, but also for possible financial gain.

In light of this, this book contains recent advances and technologies in the aforementioned fields, indicating the future trends in nonconventional precision machining processes. More specifically, a work that uses brushing with bonded abrasives as a finishing process for ceramics is presented [1]. The processing of zirconium dioxide workpieces with brushing tools of polycrystalline diamond bonded grains is considered. The goal of the investigation is the reduction in grinding-related surface defects, the preservation of surface roughness and workpiece form and the evaluation of tool wear in the case of brushing ceramic materials. It was found, by microscopical and surface topography measurements, that the brushing velocity and the grain size play the most significant role. Considering that the material removal mechanisms of abrasive brushing ceramics is largely unknown, this work is one of few dealing with this specific topic.

In the second work [2], a honing cell, incorporating a thermographic camera, a sound intensity meter, and software for collecting and analyzing data received during the process, on a CNC honing machine, are proposed. With the aforementioned arrangement, images from the thermographic camera are analyzed online and the level of sound intensity obtained during honing is continuously monitored, with the purpose of online control of the process and its optimization. For further reductions in the temperature of the workpiece due to its interaction with the tool and the subsequent deformations, the machining cell may make an automatic selection of the grain trajectory shape, with specified value of the curvature radii of the abrasive grain trajectories, according to the wall thickness of the honed workpiece. The proposed scheme is able to increase the efficiency of the process by about 20-fold.

The next work [3] also pertains to honing and, more specifically, to the possibility of employing wavelet analysis in order to evaluate the changes in the geometrical structure of a surface that arise when honing with whetstones of variable granularity. The basics of the wavelet analysis and the differences between filtering with standardized filters, Fourier analysis are described and an analysis of the results obtained when measuring the surface roughness with other wavelets is given. As a case study, honing of a four-cylinder combustion engine was used, where roughness measurements of 3D spatial structures of the machined liners were carried out. The work results in the creation of basic recommendations for the selection of wavelets when assessing honed surfaces with different degrees of regularity of the traces that were generated on them.

The effect of burnishing on heavily loaded structural elements operating in a corrosive environment is the subject of [4]. The research presents a fatigue resistance test performed on elements operating in seawater, namely, a ship propeller, where various processing parameters of burnishing applied to samples are compared to specimens with a grinded surface. The results indicate a 30% higher fatigue strength in a seawater environment for the burnished specimens. A device that allows for simultaneous turning and shaft burnishing with high slenderness is also presented. This device can be connected to the computerized numerical control system and an automatic process is executed according to the machining program with the aim of reducing the number of operations and cost of the process.

Single-sided lapping is considered in [5], as it is one of the most effective planarization technologies. The process has relatively complex kinematics and prediction of tool wear is critical for product quality control. To determine the profile wear of the lapping plate, a computer model which simulates abrasive grains trajectories in MATLAB is included in this work. Additionally, a data-driven technique was investigated to indicate the relationship between the tool wear uniformity and lapping parameters.

The next two papers pertain to wire electrical discharge machining (WEDM) and die-sinking electrical discharge machining (EDM). The former [6] is a precise and efficient non-conventional manufacturing solution in various industrial applications, mostly involving the use of hard-to-machine materials such as, among others, the Inconel super alloys. The present study focuses on exploring the effect of selected control parameters, including pulse duration, pulse-off time and the dielectric flow pressure, on the WEDM process performance characteristics of Inconel 617 material. Parameters such as volumetric material removal rate, the dimensional accuracy of cutting and surface roughness are considered, in an experimental work that was carried out with the Box–Behnken design scheme and analyzed through the response surface methodology analysis of variance (ANOVA) tests. The latter study [7], an experimental investigation of the EDM of aluminum alloy Al5052, is presented. A full-scale experimental work was carried out, with the pulse current and pulse-on time being the varying machining parameters. Then, polishing and etching of the perpendicular plane of the machined surfaces was performed in order to observe and measure the machined surfaces. Through analysis of variance (ANOVA), conclusions were drawn about the influence of machining conditions on the EDM performance, with consideration of the material removal rate, the surface roughness, the average white layer thickness and the heat-affected zone micro-hardness.

In the last paper [8], an analysis of the surface texture of turned parts with Length/Diameter ratios of 6 and 12 and various rigidity values, is presented. The studies pertain samples of S355JR steel and AISI 304 stainless steel, with a detailed analysis of 2D surface profiles, using a large number of parameters that could distinguish significant differences in the surface microgeometry. The obtained results indicated significantly better roughness and waviness values of the AISI 304 steel surface in terms of its size, periodicity, and regularity; the turning process of AISI 304 shafts with low rigidity helps to achieve a better-quality texture and has a positive effect on the general properties of a workpiece. Furthermore, it was concluded that the shafts with an L/D ratio of 12 had worse surfaces in the first two sections due to lower rigidity, while the results close to the three-jaw chuck, regardless of the L/D ratio and material type, demonstrated similar waviness and roughness parameters and profiles.

The guest editors of this Special Issue would like to thank the authors for their valuable high-quality work, the reviewers for their efforts and time spent to improve the submissions, and the publishers for their excellent work and cooperation.

Author Contributions: Conceptualization, M.D. and A.P.M.; writing—original draft preparation, M.D. and A.P.M.; writing—review and editing, M.D. and A.P.M. Both authors have read and agreed to the published version of the manuscript.

Conflicts of Interest: The authors declare no conflict of interest.

References

1. Uhlmann, E.; Hoyer, A. Surface Finishing of Zirconium Dioxide with Abrasive Brushing Tools. *Machines* **2020**, *8*, 89. [CrossRef]
2. Barylski, A.; Sender, P. The Proposition of an Automated Honing Cell with Advanced Monitoring. *Machines* **2020**, *8*, 70. [CrossRef]
3. Karolczak, P.; Kowalski, M.; Wiśniewska, M. Analysis of the Possibility of Using Wavelet Transform to Assess the Condition of the Surface Layer of Elements with Flat-Top Structures. *Machines* **2020**, *8*, 65. [CrossRef]
4. Dzionk, S.; Przybylski, W.; Ścibiorski, B. The Possibilities of Improving the Fatigue Durability of the Ship Propeller Shaft by Burnishing Process. *Machines* **2020**, *8*, 63. [CrossRef]
5. Piotrowski, N. Tool Wear Prediction in Single-Sided Lapping Process. *Machines* **2020**, *8*, 59. [CrossRef]
6. Dzionk, S.; Siemiątkowski, M.S. Studying the Effect of Working Conditions on WEDM Machining Performance of Super Alloy Inconel 617. *Machines* **2020**, *8*, 54. [CrossRef]
7. Markopoulos, A.P.; Papazoglou, E.-L.; Karmiris-Obratański, P. Experimental Study on the Influence of Machining Conditions on the Quality of Electrical Discharge Machined Surfaces of aluminum alloy Al5052. *Machines* **2020**, *8*, 12. [CrossRef]
8. Dobrzynski, M.; Mietka, K. Surface Texture after Turning for Various Workpiece Rigidities. *Machines* **2021**, *9*, 9. [CrossRef]