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PREFACE

Finish manufacturing processes are final stage processing techniques which are deployed to bring products to a stage where they are ready for marketing and putting in service. Over recent decades, a number of finish manufacturing processes have been developed by researchers and technologists. Some of these new processes have been documented and illustrated both individually and collectively in relation to application in specific areas. The advancement of tools of physics has resulted in considerable changes to these processes, and the precision with which they can be applied. The reporting of these developments are sometimes fragmentary, and this reference work provides a more connected and thorough review of these processes.

*Comprehensive Materials Finishing* is the primary reference source for researchers at different levels and stages in their career both in academia and industry. This reference work encompasses the knowledge and understanding of many experts into a single, comprehensive work. Containing a combination of review articles, case studies, and research findings resulting from research and development activities in both industrial and academic domains, this reference work focuses on how some of these finish manufacturing processes are advantageous for a broad range of technologies. These include applicability, energy and technological costs, and practicability of implementation. A wide range of materials such as ferrous, nonferrous, and polymeric materials are covered.

This work details the three foremost and distinct types of finishing processes: surface treatment, finish machining processes, and surface coating processes. Surface treatment refers to properties of a material being modified without otherwise changing the physical dimensions of the surface. Finish machining processes involve a small layer of material being removed from the surface by various machining type processes to render improved surface characteristics. Surface coating processes are where the surface properties are improved by adding fine layer(s) of materials with superior surface characteristics to improve the service life of the surface being coated. Each primary surface finishing process is presented in a separate volume, comprising chapters on many of the following relevant specific processes as follows:

Volume 1: Finish Machining and Net-Shape Forming: developments in conventional finish machining processes (honing, lapping, polishing, burnishing, and deburring), fine grinding, free EDM, laser finishing, electrical discharge grinding (EDG), electrochemical honing (ECH), electrochemical discharge grinding (ECDG), electrochemical grinding (ECG), electrochemical turning (ECT), micro-machining process, and high-speed machining.

Volume 2: Surface and Heat Treatment Processes: This contains aspects of heat treatments, stress relieving, annealing, normalizing, hardening, tempering, austempering, martempering, carburizing (pack, liquid, gas, and post carburizing treatments), nitriding (gas and plasma), salt bath (boriding, chromizing, cyaniding, and carbonitriding), phase transformation of the outer surface (induction, flame, laser, electron beam, and anodizing).

Volume 3: Surface Coating Processes: Plating (electroplating, alloys (bronze/brass and others), chromium, dense chromium, copper and tin, gold, silver and other precious metals, zinc and nickel, electroforming, electrolest nickel, hot dip galvanizing, selective/brush plating, surface finish coatings, air spray painting, and chemical vapor deposition (CVD)).

Finishing processes are at the core of successful production of marketable products and address recent progress in materials finishing technologies and science as well as covering recent developments in specific manufacturing processes involved with finishing of products for applications in all areas of engineering, biomedical, environmental, health and safety, and monitoring and control. The in-depth study of these finishing processes as presented in these volumes will assist scientists and engineers in the selection, design, and usage of materials, whether required in small- or large-scale uses across industries.

The initiations for this project began in 2014 and by January, 2015, I had selected the volume editors – Bekir Yilbas, Imtiaz Choudhury, and Shahjahan Mridha and we met with Gemma Tomalin, Joanne Williams, and Graham Nisbet at the Elsevier office in Oxford to finalize the table of contents and plan the project. Throughout 2015, the volume editors and I worked resolutely to select topics to be covered, invite authors, and review their manuscripts, eventually getting all content ready for production by the end of 2015. In 2016, authors returned their proof corrections and final files were produced. To create a work of this scale, the most in-depth reference ever published on materials finishing processes and surface engineering, relies on a collaboration of authors, editors, and the team at Elsevier. I would like to thank the many dedicated authors, whose contributions will be an essential reference for materials scientists and engineers. Each chapter has been reviewed by one of the volume editors, leading experts in their fields, whose knowledge and expertise have proved invaluable. I am indebted to each volume editor and their dedication to making their volume an exhaustive and relevant resource for the scientific community for many years to come. Finally, on behalf of myself and the volume editors, I would like to thank Gemma Tomalin and Joanne Williams at Elsevier for their support, cooperation, and good humor throughout this project – from the first meeting in early 2015, to the publication mid-2016.

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Editor-in-Chief
Dublin City University, Dublin, Ireland
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1.10.1 Introduction

According to the CRIP committee of physical and chemical processes, micro-machining is considered as one of the most fundamental technologies to manufacture and miniaturize products and parts with a dimension between 1 and 999 μm. Miniaturized products and parts are mainly used in biotechnology, information technology, environmental, medical industries, electric devices, miniaturized machines, and so on. With the recent advancements in Microelectro Mechanical System, micro-machining is being more and more popular day-by-day. A lot of studies have already been done about the fabrication of functional micro-structure and component. Basically, micromachining has been classified into three processes including conventional material removal processes, non-conventional material removal processes, and hybridized processes.

1.10.2 Material Removal Processes

1.10.2.1 Conventional Process

Mechanical force and energy are required for conventional material removal processes where shear force removes the material. Shear refers to simple machining process by physical contact between material and cutting tools. Traditional material removal processes such as micro-turning, micro-milling, micro-drilling, and grinding use a single-point diamond cutter or very fine-grit-sized grinding wheels to produce machine parts. They can be used for machining of the most of the materials; for example, ferrous and non-ferrous metals, semiconductors, and plastics. The products with any shape such as flat surfaces, arbitral curvature, long shaft, and so on can be fabricated by conventional material removal processes. Figure 1 presents the experimental setup for micro-turning, micro-milling, and micro-grinding.

1.10.2.2 Nonconventional Process

In the nonconventional process, other sources of energy such as light energy, spark energy, vibration energy, electrolysis energy, energy beams (laser beam, electron beam, or ion beams), mechanical energy (based on erosion mechanism), etc., are used to remove the material. Techniques based on energy beams (beam-based micromachining) or solid cutting tools (tool-based micromachining) can be used for micro-machining. There are some constraints due to poor control of 3D structures, low material removal rate (MRR) and low aspect ratio in the beam-based micro-machining by using the laser beam, ion beams, or electron beam. Furthermore, special facilities are required for these processes and the maximum achievable thickness is relatively small. Also, due to its quasi-three-dimensional structure, there are some limitations in using photolithography on silicon substrates includes its low aspect ratio and limitation of the work material. High aspect ratio of three-dimensional submicron structures by very high form accuracy can be produced deep X-ray lithography using synchrotron radiation beam (LIGA) process and focused-ion beam machining process. While the special facilities are required for these processes and the
Micro-EDM Drilling of Tungsten Carbide Using Microelectrode with High Aspect Ratio

Figure 1  (a) Micro-turning setup,10 (b) Close view of the micro-milling experimental setup,11 (c) Micro-grinding system setup.12,13

1. Piezoelectric Dynamometer
2. Encoder drive
3. Variable frequency drive
4. Servo motor with encoder
5. Spindle with inbuilt motor
6. Micrometer
7. Coated carbide tool
8. Tool holder
9. Dial gauge

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<tr>
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<td>-</td>
<td>MS-(AlTi)N</td>
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1.10.8 Conclusions

This work describes EDM and micro-EDM comprehensively and compares the types of pulse generators, electrodes and methods for calculating MRR, EWR, overcut, and surface roughness for these methods. Various fabrication and measurement processes of microelectrode are explained as well. Moreover, this research work was carried out to characterize the effects of micro-EDM drilling of WC–16%Co with a CuW microelectrode by using EDM machine. The results show that:

- Various machining conditions produced different amounts of overcut.
- ANOVA analysis illustrated that MRR increased with amplifying current, rotating speed and capacitor, and decreasing voltage and pulse-ON time. The current and capacitor were the most significant factors, but the effect of the capacitor was greater than current. It can be concluded that the capacitor had the greatest impact on improving MRR. Moreover, EWR increased by increasing current and pulse-ON time and decreasing pulse-OFF time. The effect of pulse-ON time on EWR was more prominent than other parameters.
- It was found there were direct relationships between the surface finish of micro-holes, burr-like recast layer at the top surfaces and MRR. It can be concluded that surface roughness enhanced and the amount of burr-like recast layer at the top surfaces decreased with decreasing current, rotating speed and capacitor, and increasing voltage and pulse-ON time. The current and capacitor were the most significant factors; however, the effect of the capacitor was greater than current.
- Pulse-OFF time and rotating speed had no effect on the amount of micro-cracks due to the insignificant effect on electrical discharge energy. On the other hand, the electrical discharge energy depends on the voltage, current, pulse-ON time, and capacitor. It can be concluded that amount of the micro-cracks decrease with increasing voltage and decreasing current, pulse-ON time and capacitor. The voltage, current, pulse-ON time, and capacitor were significant factors contributing to the amount of micro-cracks. However, the effects of voltage, current, and capacitor were stronger than pulse-ON time.
- Al was added to the recast layer at the wall of the micro-holes, and because aluminum powder was used in the dielectric, aluminum migrated to the machined surface and recast layer. The amount of C and O in the recast layer increased because oil-based dielectric was used. As a result, it is suggested to use powder that is more similar in terms of elemental composition to the workpiece in dielectric. Finally, various machining conditions produced different amounts of overcut.
- In conclusion, EDM can be used confidently for producing micro-holes.

Acknowledgment

The authors would like to acknowledge the University of Malaya for providing the necessary facilities and resources for this research. This research was funded by the University of Malaya Research Grant (UMRG) Program No. RP039B-15AET and Postgraduate Research Grant (PPP) Program No. PG027-2015A.

See also: 1.7 Techniques to Improve EDM Capabilities: A Review

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Note
This index is in letter-by-letter order, whereby hyphens and spaces within index headings are ignored in the alphabetization, and it is arranged in set-out style, with a maximum of three levels of heading.

Cross-reference terms in italics are general cross-references, or refer to subentry terms within the main entry (the main entry is not repeated to save space).

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