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Editorial

Advances and Trends in Non-Conventional, Abrasive and Precision Machining 2021

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Advances and Trends in Non-conventional, Abrasive and Precision Machining 2021. In the modern, rapidly evolving industrial landscape, the quest for machining and production processes consistently delivering superior quality and precision is more pronounced than ever. This necessity and imperative are driven by the increasing complexity in the design and manufacturing of mechanical components, an evolution in lockstep with the swift advancements in material science. The real challenge of this evolution lies in the strategic integration and continuous development of novel machining methods and processes within the manufacturing sphere. Non-conventional machining processes, standing in contrast to their conventional counterparts, exploit alternative forms of energy, including thermal, electrical, and chemical, to form and/or remove material. These innovative processes are distinguished and characterized by their utilization of high-power density energy sources, high accuracy, and the capability to machine complex and design-demanding geometries. Among these techniques are Electrical Discharge Machining (EDM), Electrochemical Machining (ECM), laser processing, and laser-assisted machining, each heralding a new era of precision and capability in manufacturing. Simultaneously, abrasive processes such as grinding, lapping, polishing, and superfinishing are undergoing relentless advancement, continuously pushing the boundaries of efficiency and surface finish quality. These methods are pivotal in achieving the highest surface finishes and are instrumental in the pursuit of advancement in manufacturing.

This increasing interest in exploring and enhancing these advanced non-conventional and precision machining processes is evident in their heightened scientific and industrial/commercial attention. Research in this area is advancing on multiple fronts, encompassing both experimental investigations and the exploration of modeling and simulation, leveraging the surge in computational power. The embrace of multiphysics, multidisciplinary, and multiscale modeling approaches is proving to be a game-changer, significantly augmenting the aim to optimize existing non-conventional machining processes and paving the way for the inception of groundbreaking new methodologies.

As industries increasingly adopt these innovative machining methods and processes, the research focus is expanding beyond the realms of academic and scientific interest. The economic implications of these advancements are profound, promising to revolutionize manufacturing processes and usher in substantial financial returns.

In the current book, the first study pertains to a multi-objective optimization of material removal rate and tool wear in rough honing processes (Contribution 1). Regression models for the material removal rate (MRR) and tool wear in rough honing processes have been developed. The experimental tests were conducted based on a central composite design, focusing on five variables: abrasive grain size, abrasive density, pressure of the stones against the cylinder's internal surface, tangential speed (in this case, corresponding to the rotation speed of the cylinder), and the honing head's linear speed. Moreover,

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multi-objective optimization was implemented to maximize the MRR and minimize tool wear simultaneously. The findings suggest that within the explored range, the MRR is primarily influenced by tangential speed, followed by grain size and pressure. Conversely, tool wear is predominantly affected by abrasive density and, to a lesser extent, pressure, tangential speed, and grain size. In addition, the multi-objective optimization results in equal prioritization of MRR and tool wear, the adoption of high grain size, high abrasive density, high tangential speed, and low pressure. In this context, linear speed minimizes the impact on the MRR and tool wear. However, if MRR is deemed more crucial than tool wear, it is advised to maintain the same settings but opt for high pressure. On the other hand, if minimizing tool wear is prioritized, a lower grain size of 128 [1] and a reduced tangential speed of approximately 166 min^{-1} are recommended, while abrasive density and pressure remain relatively unchanged from the initial scenario. In the next work, the influence of the material type and the placement in the print chamber on the roughness of MJF-printed 3d objects is studied (Contribution 2). In more detail, the samples were categorized into three groups according to the materials used: polypropylene (PP), thermoplastic polyurethane (TPU), and polyamide 11 (PA11). Meanwhile, the surface roughness was assessed based on Ra, Rq, and Rz parameters. Based on the results, the TPU samples exhibited significantly higher surface roughness than the PP and PA11 samples, which showed similar roughness levels. Finally, it was observed that surfaces printed vertically (along the Z-axis) and surfaces of TPU objects positioned in the central zones of the print chamber during printing tended to be less smooth. The next paper discusses the optimization during the sharpening process of hybrid-bonded diamond grinding wheels (Contribution 3). The study underscores the potential of a CNC-controlled sharpening process to enhance the reproducibility of grinding processes and diminish secondary processing time. This, in turn, could significantly increase the economic efficiency. Experimental research was conducted to pinpoint the crucial parameters influencing grinding wheel topography to optimize the sharpening process. The width of the sharpening block, the grain size of the sharpening block, and the area-related material removal in sharpening emerged as the most significant factors. Furthermore, additional experiments were carried out to quantify the significant sharpening parameters' influence further. Based on that, a process model was developed to predict the required sharpening parameters for certain target topographies. The authors suggest that constant work results and improved process reliability can be obtained using the process model. The fourth study presents a parametric optimization of surface quality for fabricating a titanium microchannel using the Taguchi method in electropolishing (Contribution 4). More specifically, the Taguchi method was implemented to define the optimal process parameters for achieving high surface quality, utilizing an L_9 orthogonal array. The three machining process parameters were the applied voltage, ethanol concentration in the electrolyte solution and the machining gap. These parameters were analyzed using the Pareto Analysis of Variance. Moreover, to further assess the performance of the fabricated microchannel, in vitro experiments were carried out, focusing on the fouling effect of blood on the microchannel's surface. The findings indicate that the most favorable machining parameters for enhancing the surface quality of a titanium microchannel are an applied voltage of 20 V, an ethanol concentration of 20 vol.%, and a machining gap of 10 mm. Under these optimized conditions, the surface quality of the microchannel exhibited a significant improvement, reducing from 1.46 μm to 0.22 μm. Furthermore, the experiments demonstrated a considerable reduction in the adhesion of blood on the microchannel's surface during the fouling tests. These results indicate the enhancement in surface quality and confirm the efficacy of the applied method in minimizing fouling, which is a crucial factor for the practical application of such microchannels. The next work pertains to the on-machine measurement and error compensation for a 6061 aluminum alloy hexagonal punch using a turn-milling machine (Contribution 5). A contact measurement system was integrated into a CNC combined turning-milling machine for on-machine measurement. Macro-programming was utilized to design the machining path for fabricating a hexagonal punch from A6061-T6 aluminum alloy. The process was augmented by incorporating probe measurement actions into the machining path. When the measured data exceeded the predetermined tolerance range, the calculated data were automatically fed back to the machine's controller, allowing for real-time machining adjustments and compensation. The final dimensions of the manufactured hexagonal punch were subsequently verified using a 3D coordinate measuring machine, and the results were compared to assess accuracy. The experimental findings highlighted the necessity for initial correction of the contact probe before the machining, while the post-correction achieved workpiece tolerance within the tight range of ± 0.01 mm. Furthermore, the study observed that the dimensional accuracy during rough machining was inferior to that during fine machining. It was also noted that the size error associated with rough machining tended to increase proportionally with the length of the workpiece. This underscores the critical importance of precision in the initial stages of machining and the potential impact of workpiece dimensions on machining accuracy. The sixth paper presents the importance of a slicer selection for the 3D printing process parameters via the investigation of g-code readings (Contribution 6). The primary objective was to examine how changes made by the slicer in kinematic and geometric properties affect the printing process, as interpreted from the G-code. The paper provides comprehensive definitions and formulas essential for understanding the configuration of the slicer. The authors conducted an in-depth analysis of the mesoscale geometric implications of the slicer settings. Additionally, the study proposed and verified certain modifications to the slicer properties. These adjustments aimed to align the geometric and kinematic characteristics of the printed part more closely, enhancing the overall precision and quality of the 3D printing process. The next paper discusses the ability to produce angular details accurately by 3D printing plastic parts (Contribution 7). An experimental investigation was carried out to highlight the influence of different parameters, such as the thickness of the deposited material layer, the printing speed, the cooling and filling conditions of the 3D-printed part, and the thickness of the sample. Samples using areas in the form of isosceles triangles with constant height or bases with the same length, respectively, were used. The experimental results' mathematical and statistical post-process allowed the establishment of empirical mathematical models of the power-function type and the detection of both the direction of actions and the intensity of the influence exerted by the input factors. It is also deduced that the strongest influence on the printer's ability to produce fine detail, from the point of view addressed in the paper, is exerted by the vertex angle, whose reduction leads to a decrease in printing accuracy. The following paper pertains to a simulation of the circulating motion of the working medium and metal removal during multi-energy processing under vibration and centrifugal forces (Contribution 8). More specifically, the rotational motion of the medium granules, influenced by an impeller installed at the bottom of a cylindrical reservoir, is considered. This study obtains the dependencies of the abrasive granules' circulation velocity and the circulation flow's pressure on the cylindrical reservoir's radius in a vibrating machine for different impeller rotation speeds. Additionally, the velocities of the abrasive granules at various distances from the center of the cylindrical reservoir have been determined. The amplitudes of the tangential and radial components of the pseudo-gas velocity, composed of abrasive granules, are derived. The total pressure exerted on the surface of the processed part and the average velocity of the abrasive granules colliding with it are also determined. Graphical dependencies of the integral metal removal on the amplitude and frequency of the reservoir wall oscillations in the vibrating machine are presented, considering various angular velocities of the impeller rotation. The ninth paper presents a new finishing process combining a fixed abrasive polishing with magnetic abrasive finishing process (Contribution 9). Namely, a novel finishing process that integrates magnetic abrasive finishing with fixed abrasive polishing (MAF-FAP) is introduced. A specialized finishing device was developed to validate the proposed methodology, and experiments were conducted on alumina ceramic plates. The study also delves into the mechanism underlying the Magnetic Abrasive Finishing- Fixed Abrasive Polishing process. Additionally, it examines the impact of various process parameters on the finishing characteristics. The experimental outcomes indicate that this process can efficiently finish brittle, hard materials like alumina ceramics and achieve nano-scale surface textures. Notably, the surface roughness of the alumina ceramic plate improved significantly, dropping from 202.11 nm Ra to 3.67 nm Ra within 30 min. The tenth paper examines the surface quality obtained during trochoidal milling of 6082 aluminum alloy (Contribution 10). In more detail, an alternative strategy for slot milling, known as trochoidal milling, utilizes a more complex trajectory for the cutting tool and was comprehensively studied. To assess the capabilities of trochoidal milling, two series of experiments were conducted, comparing traditional and trochoidal milling under various feed rates and cutting speed conditions. The results demonstrated a clear difference between the two milling strategies, highlighting that trochoidal milling can achieve superior surface quality when combined with optimal process parameters. Moreover, the study investigated the influence of the depth of cut, coolant application, and trochoidal stepover on surface roughness during trochoidal milling. It was concluded that lower cut depths, coolant application, and minimal trochoidal stepover values contribute significantly to reducing surface roughness. Finally, an adaptive cutting control for roadheaders based on performance optimization is presented (Contribution 11). Initially, cylinder pressure and motor current are utilized as criteria to detect load changes. Particle swarm optimization is employed to fine-tune the cutting parameters under varying impedances. Subsequently, a fuzzy neural network is used to establish the relationship between cutting speed, motor current, and cylinder pressure by training the cutting and identification parameters under different conditions. Ultimately, vector control of the motor and the electro-hydraulic servo valve is implemented to regulate the cutting speed. The results indicate that the cutting unit can adapt to diverse load signals, consistently maintaining the road header's optimal working condition. The rotation speed adjustment of the cutting head stabilizes after 0.05 s, with an overshoot of 1.42%, while the swing speed regulation stabilizes after 1 s, with an overshoot of 5.3%. These conclusions offer a foundation for enhancing the cutting efficiency and extending the operational lifespan of the roadheader.

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