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Editorial

Friction and Wear of Cutting Tools and Cutting Tool Materials

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The friction between cutting tools and the workpiece/chip can significantly affect the tool wear, cutting force, cutting temperature, machined surface integrity, and machined parts' service performance. The friction and wear of cutting tools have long been a focus of researchers. In recent years, the development of new cutting methods and cutting tools, such as ultrasonic-vibration-assisted cutting, cryogenic cutting, MQL cutting, and micro-textured tools, has changed the friction and wear rules of cutting tools. This Special Issue presents the latest advances in the fields of the friction and wear of cutting tools and cutting tool materials.

This Special Issue contains 14 papers covering the design of anti-wear micro-textures/coatings, the development of new lubricating methods, cutting process modeling, and the analysis of friction mechanisms.

Xu et al. (Contribution 13) proposed a bionic microstructure tool based on shells, and found that composite bionic micro-textured tools have a significantly reduced cutting force compared with non-micro-textured tools. Composite bionic micro-textured tools lead to a reduction in surface roughness of 10–25%, and composite bionic micro-textured tools are more prone to enhancing the curling and breaking of chips. In addition, with the increase in the microstructure area occupancy, the cutting performance of the tool was significantly improved. Hu et al. (Contribution 8) designed micro-textured tools with five different morphologies and studied the influence of the different micro-texture morphologies on the tool wear during spray cooling. The wear area of the rake face was measured based on the infinitesimal method, and the optimal morphology with the best anti-wear ability was obtained. Warcholinski et al. (Contribution 5) presented an evaluation of the surface quality and properties of multilayer coatings. The results indicated that the melting point of the cathode material directly affected the number and size of the macroparticles on the surface of the growing coating. The number of macroparticles increased with the lowering of the melting point of the cathode material. Feng et al. (Contribution 3) proposed a multi-objective optimization design method for the micro-texture parameters of a cutting tool. Taking a relatively low cutting force, cutting temperature, and tool wear as the objectives, a genetic algorithm multi-objective optimization model for the micro-texture parameters of the tools was established, and the model was solved using the NSGA-II algorithm to obtain a Pareto solution set and micro-texture parameters with good, comprehensive cutting performance.

In terms of modeling the cutting processes, Huang et al. (Contribution 14) proposed a tool wear prediction model by combining multi-channel 1D convolutional neural networks (1D-CNNs) with temporal convolutional networks (TCNs). Zhou et al. (Contribution 12) established a cohesive element model to perform crack propagation simulation in nanocomposite ceramic tool materials by introducing cohesive elements with fracture criteria into microstructure models. The influences of nanoparticle size, microstructure type,

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nanoparticle volume content, and interface fracture energy were analyzed, respectively. Yu et al. (Contribution 9) acquired regression models of the sawing force and temperature rise based on the response surface methodology (RSM) experiments of bone sawing. The sawing parameters for minimizing force and temperature were recommended. Cui et al. (Contribution 7) proposed a thermodynamic analysis model to evaluate the cutting force and tool design in milling. The model comprehensively considers the tool angle and quickly calculates the minimum load on the milling cutter based on the optimal geometric parameters. Li et al. (Contribution 4) established a multi-objective function by processing the physical signals in the grinding process, which considered grinding parameters, i.e., surface roughness, coefficient of friction, active energy consumption, and effective grinding time. The weight vector coefficients of the sub-objective functions were optimized through a multi-objective evolutionary algorithm based on the decomposition (MOEA/D) algorithm.

Meng et al. (Contribution 11) studied the tool wear mechanism considering the tool–chip interface temperature during milling of aluminum alloy. Adhesion wear is the main wear mechanism of the high-speed milling of ADC12 aluminum alloy. The most important factor affecting adhesion wear is the tool–chip interface friction, which is directly manifested in the tool–chip interface temperature. With the increase in temperature, the tool wear rate increases; the molten adhesive layer on the tool surface is accompanied by crack propagation; and adhesion wear, oxidation wear, and abrasive wear occur on the tool surface. Xu et al. (Contribution 6) fabricated a high-wear-resistance coating via the synergy of laser cladding and ultrasonic burnishing. Li et al. (Contribution 2) studied the influence of cutting parameters on tool wear during the carbide tool milling of GH4169 and a tool wear prediction model was obtained. Ultrasonic vibration milling was compared with ordinary milling, and the improvement degree of the different coating materials on carbide tool wear was explored.

Finally, Liu et al. (Contribution 10) and Wang et al. (Contribution 1) studied the influence of new lubricating methods on the tool wear and cutting performance. Liu et al. (Contribution 10) presented a new method of combining nanofluid MQL with ultrasonic vibration assistance in a turning process. The results show that the new method with graphene nanosheets can further improve the machining performance by reducing the specific cutting energy and areal surface roughness, compared with the NMQL turning process and UVAT process. Wang et al. (Contribution 1) discussed the feasibility of machining γ-TiAl in cryogenic LN2 cooling conditions. It was found that cryogenic machining shows significant advantages in reducing cutting force, suppressing heat-affected zones, improving surface quality, and inhibiting micro-lamellar deformation.

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

List of Contributions

1. Wang, X.; Zhang, X.; Pan, D.; Niu, J.; Fu, X.; Qiao, Y. Tool Wear and Surface Integrity of γ-TiAl Cryogenic Coolant Machining at Various Cutting Speed Levels. *Lubricants* **2023**, *11*, 238. https://doi.org/10.3390/lubricants11060238.
2. Li, X.; Zhang, W.; Miao, L.; Pang, Z. Analysis of Tool Wear in GH4169 Material Milling Process. *Lubricants* **2023**, *11*, 245. https://doi.org/10.3390/lubricants11060245.
3. Feng, X.; Fan, X.; Hu, J.; Wei, J. Multi-Objective Optimization Design of Micro-Texture Parameters of Tool for Cutting GH4169 during Spray Cooling. *Lubricants* **2023**, *11*, 249. https://doi.org/10.3390/lubricants11060249.

4. Li, Y.; Jiao, L.; Liu, Y.; Tian, Y.; Qiu, T.; Zhou, T.; Wang, X.; Zhao, B. Study on a Novel Strategy for High-Quality Grinding Surface Based on the Coefficient of Friction. *Lubricants* **2023**, *11*, 351. https://doi.org/10.3390/lubricants11080351.
5. Warcholinski, B.; Gilewicz, A.; Tarnowska, M. The Surface Assessment and the Properties of Selected Multilayer Coatings. *Lubricants* **2023**, *11*, 371. https://doi.org/10.3390/lubricants11090371.
6. Xu, N.; Jiang, X.; Shen, X.; Peng, H. Improving the Surface Integrity and Tribological Behavior of a High-Temperature Friction Surface via the Synergy of Laser Cladding and Ultrasonic Burnishing. *Lubricants* **2023**, *11*, 379. https://doi.org/10.3390/lubricants11090379.
7. Cui, J.; Shen, X.; Xin, Z.; Lu, H.; Shi, Y.; Huang, X.; Sun, B. Thermodynamic Analysis Based on the ZL205A Alloy Milling Force Model Study. *Lubricants* **2023**, *11*, 390. https://doi.org/10.3390/lubricants11090390.
8. Hu, J.; Wei, J.; Feng, X.; Liu, Z. Research on Wear of Micro-Textured Tools in Turning GH4169 during Spray Cooling. *Lubricants* **2023**, *11*, 439. https://doi.org/10.3390/lubricants11100439.
9. Yu, D.; Zou, F.; Zhang, W.; An, Q.; Nie, P. Measurement and Prediction of Sawing Characteristics Using Dental Reciprocating Saws: A Pilot Study on Fresh Bovine Scapula. *Lubricants* **2023**, *11*, 441. https://doi.org/10.3390/lubricants11100441.
10. Liu, G.; Wang, J.; Zheng, J.; Ji, M.; Wang, X. An Experimental Study on Ultrasonic Vibration-Assisted Turning of Aluminum Alloy 6061 with Vegetable Oil-Based Nanofluid Minimum Quantity Lubrication. *Lubricants* **2023**, *11*, 470. https://doi.org/10.3390/lubricants11110470.
11. Meng, X.; Lin, Y.; Mi, S.; Zhang, P. The Study of Tool Wear Mechanism Considering the Tool–Chip Interface Temperature during Milling of Aluminum Alloy. *Lubricants* **2023**, *11*, 471. https://doi.org/10.3390/lubricants11110471.
12. Zhou, T.; Meng, L.; Yi, M.; Xu, C. Simulation of Microscopic Fracture Behavior in Nanocomposite Ceramic Tool Materials. *Lubricants* **2023**, *11*, 489. https://doi.org/10.3390/lubricants11110489.
13. Xu, T.; Ma, C.; Shi, H.; Xiao, K.; Liu, J.; Li, Q. Effect of Composite Bionic Micro-Texture on Cutting Performance of Tools. *Lubricants* **2024**, *12*, 4. https://doi.org/10.3390/lubricants12010004.
14. Huang, M.; Xie, X.; Sun, W.; Li, Y. Tool Wear Prediction Model Using Multi-Channel 1D Convolutional Neural Network and Temporal Convolutional Network. *Lubricants* **2024**, *12*, 36. https://doi.org/10.3390/lubricants12020036.

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