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EDITORIAL

Enhanced manufacture technology based on emission reduction and carbon reduction in cutting and grinding

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Cutting fluid has the effect of reducing cutting force, cutting temperature, improving tool life, etc., which has been widely used in traditional machining. According to statistics, the global annual consumption of cutting fluid is more than 4 million tons. However, with the improvement of carbon reduction and emission reduction requirements, cutting fluids have been unable to meet the future requirements of green manufacturing and sustainable manufacturing due to the problems of unfriendly environment and non-renewable energy. Currently, green and sustainable manufacturing has become a hot topic in the manufacturing industry. Emerging sustainable technologies (e.g., dry condition, minimum quantity lubrication) have been increasingly reported and preliminarily validated. However, there are some limitations under various conditions (e.g., grinding, cutting, milling) and application areas (e.g., aerospace and automotive). Therefore, more attention should be focused on improving machining performance (e.g., reduced energy consumption, improved efficiency and quality, suppression of machining defects) as well as understanding unknown mechanisms (e.g., atomization, penetration, film formation, and thermal stability of the bio-lubricant) by combining existing green and assistive technologies (e.g., ultrasonic vibration–assisted and nanoenhanced bio-lubricants), which can provide theoretical and technical support for the machining of key components in aerospace, rail transportation, automotive, marine, semiconductor, and other fields and accelerate the application of related technologies.

On this basis, the authors' team has planned a special issue entitled "Enhanced manufacture technology based on emission reduction and carbon reduction in cutting and grinding," which aims to solve the problems of unclear mechanism of multi-field empowerment-assisted machining cutting and grinding, lack of lubricant atomization, penetration, film formation and thermal destabilization mechanism, and bottlenecks of insufficient sustainable manufacturing strategy.

1 Multi-energy field assistance technologies

1.1 Ultrasonic assistance technologies

It has been proven that ultrasonic assistance can improve machining performance. At the aspect of grinding, Cheng et al. [1] investigated the grinding forces and the surface quality by conducting comparative experiments on axial and composite ultrasonic vibration–assisted face grinding using a single diamond. The effects of ultrasonic vibration amplitude and wheel speed on grinding forces, ground surface roughness, and ground surface morphology were analyzed to reveal the brittle–ductile removal behavior of SiC ceramics during the microcutting process caused by elliptic ultrasonic vibration. It found that composite ultrasonic vibration–assisted face grinding can effectively reduce the grinding forces by about 15%, reduce the ground surface roughness by approximately 40.7%, and induce ductile removal to acquire good surface finish with predominantly facets in comparison to axial ultrasonic vibration–assisted face grinding. Zhao et al. [2] conducted the comparative trials between ultrasonic vibration–assisted grinding and conventional grinding during ultra-high strength steel machining. The grinding performance, such as the variation of grinding force and temperature under two grinding modes, as well as the variation of tool wear morphology with the increase of grinding step and surface quality were analyzed. The results showed that the force and temperature of grinding maximum decreased by 35.5 and 39.2% compared with

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conventional grinding, respectively; a finer ground surface quality was also obtained. Zhao et al. [3] proposed a radial ultrasonic vibration–assisted grinding equipment which fabricated to achieve the reduction of tool wears and high machined surface quality in grinding particle-reinforced titanium matrix composites. Results showed that radial ultrasonic vibrating amplitudes have great influences on material removal mechanism and abrasive wear properties. The normal grinding force was increased by 5.1–14.8%, and the grinding temperature was reduced by 37.2% under the radial ultrasonic vibration–assisted grinding process. In addition, it also can facilitate the transverse expansion of cracks within the reinforcing particles and promotes microfracture behavior, leading to a significant reduction in surface defects. Ding et al. [4] studied the impact of machining parameters on material removal ratio, abrasive wear, and surface quality during single CBN grain grinding using ultrasonic machining technology. It indicated that the implementation of radial ultrasonic vibration–assisted grinding can effectively reduce the pile-up ratio from 58.3 to 17.3%. Compared to conventional grinding, radial ultrasonic vibration–assisted grinding achieves material removal via cutting and microfracture mechanisms, which effectively prevents reinforcement pull-out and significantly enhances machining quality. Jin et al. [5] studied the grinding force and surface topography during grinding SiCf/SiC ceramic matrix composites. The results showed that the cutting force is reduced by 64.4%, the surface roughness is reduced by 44.5% under longitudinal–torsional coupled rotary ultrasonic machining, and the surface topography is significantly improved, compared with conventional machining. Xiang et al. [6] analyzed the formation mechanism of ultrasonic vibration grinding and ordinary grinding of GCr15SiMn material theoretically, as well as surface morphology of by numerical simulation, and investigated the effects of different processing variables on surface roughness experimentally. The results showed that ultrasonic vibration grinding could improve the quality of the surface with lower roughness than normal grinding, and the surface roughness was reduced by more than 27%. Zhao et al. [7] investigated the effects of various parameters on the grinding forces of ultrasonic vibration–assisted grinding of alumina ceramics; the kinematic theory was combined with the effective cutting trajectory of transient single-grain abrasives and the effective removal of transient material to develop a ultrasonic vibration–assisted grinding alumina ceramic grinding force model and a ultrasonic vibration–assisted grinding end-face grinding force model. The effects of grinding parameters (grinding depth, table speed and grinding wheel speed) and ultrasonic parameters (ultrasonic amplitude) on grinding force were analyzed. The maximum relative mean error between the theoretical and experimental results was 12.3%, while the overall relative mean error was 4.94%. Bie et al. [8] proposed a two-dimensional (i.e., 2D or elliptical) ultrasonic vibration–assisted dry grinding gear to explore the grinding performance. The grain kinematics and the characteristics of grinding force and surface roughness during elliptical ultrasonic vibration–assisted dry gear grinding were theoretically substantiated. The gear grinding experiment under elliptical ultrasonic vibration–assisted dry gear grinding and conventional gear grinding was conducted to verify the analytical model. It showed that the tangential and normal grinding forces can be reduced approximately 40 and 30%, respectively; the surface roughness can be reduced by up to 25.6%. Li et al. [9] studied the optimal selection of parameters when dressing white alumina grinding wheel with ultrasonic-assisted diamond roller using response surface methodology and genetic algorithm. They analyzed the action characteristics of the dressing parameters during ultrasonic-assisted roller dressing and developed a prediction model for the surface roughness (Ra) of bearing ring grinding. The influence law of dressing parameters and their interactions on Ra was qualitatively analyzed and optimized. The results showed that the dressing speed ratio and the ultrasonic amplitude were the main influencing factors on Ra. The surface roughness was reduced by 9.77 ~ 52.68% using the optimization parameters.

At the aspect of milling, for milling performance, Zhang et al. [10] analyzed the cutting force in longitudinal–torsional ultrasonic-assisted core drilling of CFRP based on hertz contact theory and indentation depth theory. The delamination suppression mechanism was discussed from the aspects of surface morphology of hole wall, exit morphology of hole, and bottom surface morphology of blind hole. It found that the cutting force is significantly reduced in longitudinal–torsional ultrasonic-assisted core drilling compared to conventional core drilling and longitudinal ultrasonic-assisted core drilling. Wang et al. [11] proposed an ultrasonic-assisted dry helical milling technology to improve the surface quality and processing efficiency of CFRP. Taking tool rotation speed, feed rate, pitch, and ultrasonic amplitude as optimization variables and taking minimum delamination damage, burr damage, and maximum material removal rate as objective functions, multi-objective optimization models are established through experiments and genetic algorithm, and Pareto optimal solution sets are obtained. It found that the established optimization models can provide multiple parameter optimization schemes for different engineering applications with high accuracy. For surface integrity, Yan et al. [12] explored the surface formation mechanism of TC4 titanium alloy under longitudinal–torsional ultrasonic vibration–assisted micromilling by a probabilistic model. The mechanism of the intermittent cutting characteristics is analyzed by the trajectories of the tool tip, the model of the comprehensive trajectories of the tool tip is established considering the radial runout of the cutter, and a probabilistic model of the machined surface residual material height of TC4 titanium alloy is further established to predict the 3D surface morphology. In addition, the results showed that the simulation results are consistent with the experimental results, which verifies the accuracy and reliability of the theoretical model. Ming et al. [13] reconstructed the geometric-kinematic-dynamic surface topography matrix and its corresponding material elastic recovery height matrix based on tool trajectory and cutting thickness, which are then summed to obtain the geometric-kinematic-dynamic-physical surface topography matrix. The roughness parameters Ra and Rz are predicted based on the final reconstructed physical surface topography matrix. It found that Ra and Rz of ultrasonic vibration–assisted milling are on average 26 and 39% greater compared to conventional milling, respectively. Tong et al. [14] studied the formation mechanism of defects such as edge break damage and cracks during optical glass processing and established the edge break damage depth model of the export edge collapse. It found that the main reason for the edge break damage is that the optical glass will crack on the subsurface during processing, which causes the amorphous material to tear and crumble. However, ultrasonic vibration–assisted milling can significantly reduce this phenomenon, which can improve the surface and edge quality and help improve the application range of optical glass. Song et al. [15] established a mathematical model of the top burr size of slot milling titanium alloy based on the law of energy conservation and the principle of minimum energy starting from the chip deformation force to analyze the formation mechanism of burrs in longitudinal–torsional ultrasonic vibration vertical milling of titanium alloy and used experiments to verify the model conduct qualitative analysis and verification. Experimental results showed that the height and width of the burrs on the up-milling side and down milling side reached the minimum values when the ultrasonic amplitude was 3 μm, which were reduced by 75.49%, 44.33%, 89.16%, and 47.82% respectively compared with nonultrasonic processing.

At the aspect of cutting, Gu et al. [16] focused on the theoretical feasibility of generating a unique type of tool path under different parameter combinations and studies the machining effect of metal glass under this condition. It found that the frequency coefficient, amplitude, and phase difference are all important parameters that affect the characteristics of tool path and the machining effect of metallic glass. The separation characteristics formed under the appropriate parameters can reduce the cutting force by about 50%, and the roughness reduced by nearly 50% using a frequency coefficient of 2. Zhang et al. [17] established an equivalent three-dimensional simulation model of thermo-mechanical coupling based on the kinematic characteristics of turning carbide end-face. The results showed that the simulation models can predict residual stress with high accuracy, and ultrasonic-assisted vibration machining can effectively improve surface residual stresses. Wang et al. [18] established a finite element simulation model of ultrasonic-assisted cutting carbon fiber–reinforced composites to study the influence of machining methods and parameters on the surface quality of carbon fiber–reinforced composites in the cutting process. The simulation results show that the introduction of ultrasonic reduces the damage degree of CFRP in the cutting process, and the tool attached torsional ultrasonic vibration effect is the most significant. Gao et al. [19] developed the model for the mean thrust force under ultrasonic vibration assistance considering both the temperature effect and the tension–compression asymmetry of zirconium-based metallic glass according to the Mohr–Coulomb yield criterion. The impacts of spindle speed, feed rate, and ultrasonic amplitude on the thrust force and the impact of ultrasonic vibration on suppressing crack initiation and propagation were also investigate. The results showed that the mean thrust force in longitudinal–torsional ultrasonic-assisted drilling zirconium-based metallic glass decreased by 3.95–29.12% compared with that in traditional drilling and significantly reduced the thickness and diameter of the exit round cap and the number of pits caused by material chipping.

At other machining aspects, Zha et al. [20] investigated the influence mechanisms of static loads and cyclic dynamic impact loads in the ultrasonic impact–strengthening process by the developed ultrasonic impact–strengthening test platform. The force values in the static load experiments, cyclic dynamic impact experiments, and ultrasonic impact strengthening experiments were analyzed. It found that the force value in the ultrasonic impact–strengthening process is not only the superposition of the static load and the cyclic dynamic impact load, but it also indicates a coupling effect, which increased by more than 55%. In addition, the deformation strain rate, material surface hardening mechanism, and strengthening performance of Ti-6Al-4 V were also studied. Zheng et al. [21] established a model of grain refinement and residual stress in ultrasonic surface rolling and carried out the finite element simulation of 7075 aluminum alloy to discusses the influence of grain size on residual stress. The experimental results showed that compressive residual stress has a strong dependence on the grain size, and the effect of static force on compressive residual stress is more significant than that of grain refinement.

1.2 Other assistance technologies

Electric and magnetic field-assisted machining techniques have been shown to improve the machinability of workpieces. For example, Liu et al. [22] reviewed experiments of electric pulse–assisted machining (EPAM) using the electroplasticity effects (EPE) of metals and describes the use of electroplasticity in terms of plastic forming machining and cutting machining, and it also depicts the processes and benefits of EPAM. They also gave theoretical suggestions for the use and further development of electroplasticity by summarizing the current processes of electroplasticity in terms of thermal and athermal effects. Yan et al. [23] reviewed magnetic field–assisted finishing technology (MFAF) in detail. They introduced the origin and development of MFAF technology and proposes a classification method based on media. In addition, they discussed the differences of wear mechanisms and the action mechanism of composite processing and summarized the commonly used material removal models of MFAF techniques. In addition, the performance of elliptical vibration–assisted cutting (EVC) has also been proved. Lu et al. [24] studied the surface formation of BK7 optical glass processed by EVC. The removal mechanism of BK7 in EVC ductile processing was analyzed, and a critical undeformed cut depth prediction model for EVC processing BK7 was established. The experimental results showed that the critical undeformed cutting depth decreases with the increase of cutting speed and increases with the increase of vibration frequency, and the average error is only 12%, which verifies the model's accuracy. Liu et al. [25] proposed a closed-loop control approach that effectively modifies processing parameters in real time by targeting on the molten pool transient area during direct laser deposition (DLD) process. The validation experiments showed that the closed-loop processing group improved stability in maintaining the molten pool transient area, with a notable decrease of 33.7% in variability compared to the open-loop processing group.

2 Green coolant application technologies

From the action mechanism and processing properties of green lubricant application or nanoparticle-enhanced coolants aspects, it has been verified to show improved performance and in MQL compared to dry and traditional mineral oil-based cutting fluids. For review papers, Zhou et al. [26] conducted a comprehensive literature review of the progress made in the processing of nickel-based alloys using various minimum quantity lubrication (MQL) methods. The review reveals that compared to traditional MQL, vegetable oil–based MQL can result in approximately 30% improvement in surface quality and a 50% reduction in tool wear. The addition of solid lubricants to vegetable oil further enhances its lubrication performance. Cryogenic cooling–based MQL enables the attainment of finer grains and smaller sawtooth chips. Electrostatic atomization MQL, by altering the atomization process of traditional MQL, led to a 42.4% reduction in tool wear and a 47% improvement in machined surface quality. Wang et al. [27] completed a review of the process, device, and mechanism, especially the unique mechanism of nanofluid minimum quantity lubrication under different processing modes. The preparation, fluid, thermal, and tribological properties of nanofluids, as well as its performance in machining were clarified. It found that the coefficient of friction of nanofluids is reduced by 85% compared with dry conditions, which improves the tool life by 177–230% in hard milling. Furthermore, the innovative equipment used in the supply of nanofluids and the atomization mechanisms under different boundary conditions were also analyzed. Adil et al. [28] summarized graphene-based drilling fluids, carbon nanotube–based drilling fluid, and nanocellulose and its derivative-based drilling fluids investigated by various researchers. They especially highlighted the recent advances of nanoparticle-based fluids in drilling fluid system. Besides, the thermal conductivity, density, viscosity, and specific heat capacity of the nano-based drilling fluids were also critically discussed in this manuscript. For study papers, Zhang et al. [29] conducted the orthogonal test of single-grain scratches under different lubrication modes to develop an efficient processing strategy for ceramic matrix composites. It found that the utilization of minimum quantity lubrication (MQL) from vegetable oil showed the best results, with the average scratch force of 44.4 N and the average surface elevation of 26.893 μm. The reduction compared to dry lubrication was 48.3% and 48.4%, respectively. Wu et al. [30] evaluated the effect of three green cooling and lubrication conditions (i.e., dry cutting, high-pressure air cooling and ultrasonic atomized-based cutting fluid on the milling performance of ultra-high strength steel in terms of milling force, surface quality, and tool wear). Furthermore, the fast Fourier transform algorithm was also applied to quantitatively analyze the milling chatter and profile features of machined surface. It found that the ultrasonic atomization-based cutting fluid process obtained a lower cutting force, coefficient of friction, and surface roughness Ra in comparison with the dry and high-pressure air-cooling environments. Dai et al. [31] studied the cryogenic mechanical properties of cobalt-based superalloy GH605, and then, the cutting experiments were conducted under three different cooling and lubrication methods (flood condition, cryogenic minimum quantity lubrication, and liquid nitrogen) to investigate the cryogenic machinability and machining sustainability of GH605. It found that the cutting force of liquid nitrogen is reduced by up to 72.2%, the cutting-specific energy is reduced by about 83.9%, and the concentration of particulate matter such as PM2.5 generated during the processing can be decreased by more than 60% compared with the cutting fluid.

At other explorations of coolant aspects, Zou et al. [32] studied the effects of grinding wheel speed and workpiece speed on the coolant distribution law. The unidirectional flow field model in double-face grinding was established based on the contact equation of computational fluid dynamics, the Navier−Stokes equation, and the turbulence equation. The results showed that the component surface fluid velocity gradually rose from the inner to the outside diameter of the grinding wheel; there is a positive linear correlation between the grinding fluid flowing into the grinding zone and the grinding wheel speed, and 60 rad/s wheel speed leads to a more even coolant distribution and a flatter machined surface. Yang et al. [33] carried out simulation analysis of its machining process based on smoothed particle hydrodynamics with finite element method (SPH-FEM) to investigate the rail repair process based on high-pressure abrasive water jet, and the rail top surface was repaired by high-pressure abrasive water jet technology. The experimental results showed that the simulation data and experimental results were basically the same, and the repaired rail surface roughness of 2.648 μm is better than the rail milling train repair index value of 56.2%.

3 New tool technology

From tool preparation and application, new preparation methods and processing technologies have also further improved tool life and workpiece surface quality. For example, Mao et al. [34] elucidated the wear behaviors of the grinding wheel with orderly microgrooves in grinding narrow-deep slots. Through the comparative experiments of the grinding narrow-deep slot, the impacts of microgrooves on the wear behaviors of the grinding wheel are evaluated, and the wear behavior of the grains on the cut-in edge, cut-out edge, cylindrical surface, and side surface is observed, respectively. The experimental results that verified the grinding wheel with orderly microgrooves can achieve self-sharpening to maintain excellent grinding performance. Zhang et al. [35] investigated the heat transfer characteristics of profile rotating heat pipe-grinding wheel (PRHP-GW) from the perspective of different grinding heat flux, rotating speed, and grinding wheel types (normal grinding wheel without RHP, PRHP-GW filled with deionized water, and PRHP-GW filled with diamond nanofluid) using numerical simulation. The results showed that the heat transfer capacity of PRHP-GW was superior to that of the normal grinding wheel, and its heat transfer performance filled with diamond nanofluid is better than the case filled with deionized water. Fernandes et al. [36] devised and tested an innovative method of tool cooling via internally cooled tool (ICT). The developed method was compared with temperature measurements taken through thermography and a tool–workpiece thermocouple during the turning of Inconel 718. It found that the method offered outstanding heat removal capabilities and substantial advantages over cutting fluids while significantly surpassing the performance of dry machining, thereby addressing crucial concerns in sustainable machining practices. Su et al. [37] studied the effect of Ta–C-coated single-flute microdrill on its machinability in drilling of printed circuit boards. They conducted the drilling experiments and analyzed the drilling force signals, hole dimensions, hole accuracy, and tool wear. It found that the Ta–C-coated microdrill exhibited the improved chip evacuation, greater stability, and higher sustainable machinability during the drilling of PCBs. For example, with the feed rate of 5 μm/rev, the averaged thrust force and torque reduced 6.0% and 34.6%, respectively; the Ta–C-coated microdrill showed an increase of 13.5% in hole accuracy. Dong et al. [38] constructed a novel method to calculate the stability boundary of delay differential equations (DDEs) involving inconsistent delay terms for quickly and accurately calculating stability boundaries in the milling process with variable pitches using milling cutter with variable pitches. Zha et al. [39] developed the experimental setup for the cutting test of Ti-6Al-4 V with the online monitoring system using the dynamometer and infrared temperature tester to study the influence of cutting feed rate conditions on surface integrity. It found that the average error of cutting force and temperature between simulation and experiment was less than 10%. More important, the high cutting force and high cutting temperature would induce the tool wear and deterioration of surface integrity of the machined workpiece when the feed rate exceeded 0.1 mm/rev. Guo et al. [40] carried out the force analysis of the wire bow formed by the sawing process, and the relationship between the cutting force and the material removal rate was obtained from the microscopic abrasive scratching process. The wire bow prediction model of diamond wire sawing based on process parameters is founded, and the accuracy of the model is verified by experiments.

At the machining tool aspect, Zhang et al. [41] developed a prototype CNC machine tool based on the wire electrical discharge dressing method to receive in-process dress the metal-bonded diamond wheels of complex contours with the high-precision. Wire electrical discharge dressing of a metal-bonded diamond grinding wheel was performed on the developed prototype machine tool. The results showed that it could realize the dressing of the grinding wheel with a runout of less than 2 μm, and the grinding surface with Ra less than 0.8 μm was obtained. Zhang et al. [42] proposed an improved hybrid grey wolf optimization algorithm to optimize the geometric error modeling scheme of the support vector regression machine for the problem of geometric error prediction of CNC machine tools. It found that a minimum reduction of 9% in circular trajectory error and a reduction to two overruns in S-shaped test pieces after error compensation were obtained.

4 New finishing technologies

From the finishing technologies aspect, some new finishing method has been proved as the available technology to improve the efficiency and surface integrity. For example, Wang et al. [43] gave a detailed literature review on magnetorheological finishing for complex surfaces. The principle of magnetorheological finishing was introduced firstly and some new compound techniques with high machining efficiency were also introduced. Then, the researches on magnetorheological finishing influence function and force were reviewed, and the researches on three factors affecting machining performance, including process parameters, fluid, and magnetic pole arrangement, were reviewed. Finally, the key works of magnetorheological finishing technology in the future are prospected. Wang et al. [44] provided a comprehensive review and summary of the existing surface finishing technology for cylindrical rollers. A comprehensive classification and summary of the current surface finishing technologies for cylindrical rollers were provided, which include centerless grinding, superfinishing, electrochemical mechanical finishing, magnetic fluid grinding, double-side lapping, double-disc straight groove grinding, shear thickening polishing, and mass finishing. In addition, the surface roughness and roundness error ranges achieved by different finishing technologies are quantitatively compared, and their processing characteristics are comprehensive compared. Zhang et al. [45] performed polishing experiments on SiCp/Al at 15 rpm and 35 rpm, respectively, and surface integrity, including surface damage and material removal forms, was evaluated to explore the effects of different polishing speeds on it. In addition, a model was established to explore the material removal mechanism in fixed abrasive polishing (FAP). The results indicated that high-speed polishing at 35 rpm may result in better surface quality. It also found that the different material remove mechanism was obtained at high-speed polishing and low-speed polishing. Yang et al. [46] proposed a novel bidirectional composite vibratory finishing approach, which combined the power actions on abrasive particles and processed workpieces. Comparative simulations based on discrete element method (DEM) and experimental validation were performed on a cylindrical workpiece simplified by a gear. The results showed that the bidirectional composite vibratory finishing had the highest polishing efficiency, resulting in a workpiece surface roughness reduction rate up to 57% within 15 min. Li et al. [47] proposed a novel rotary barrel finishing approach, which was floating clamp, friction drive, and horizontal limit to accomplish the objective that consistency finishing of manufacturing for bearing rings. The effect of the vessel rotation speed on bearing ring's motion and media kinetic energy's distribution was investigated by the co-simulation, and the surface roughness of the workpiece was investigated by optimal finishing experiment. It found that the surface roughness of bearing ring surfaces can be improved, which demonstrated that the bearing ring surfaces can be finished simultaneously and clamed non-destructive by this finishing approach. Xue et al. [48] proposed a dry-type tribochemical mechanical polishing method for single crystal SiC substrates. The material removal characteristics of SiC substrates were investigated under different polishing pressures and rotational speeds with catalysts of Fe_2O_3 and Fe_3O_4. The results showed that the catalytic performance of the Fe_3O_4 catalyst was superior to that of the Fe_2O_3 catalyst. The addition of catalyst can improve the material removal rate which up to 709.2 nm/h, and the surface roughness as low as 2.257 nm. Tan et al. [49] proposed a novel gas–liquid–solid three-phase rotary abrasive flow polishing method (RGLSP) based on the microbubble cavitation effect. The machining experiments showed that the proposed RGLSP method can improve the machining efficiency by 60%, and the surface roughness can reach Ra 0.1 μm with lower surface defects. Zhang et al. [50] established a novel theoretical model to predict the surface roughness of the workpiece processed by cerium oxide (CeO_2) slurry-enhanced grinding considering the effects of the protrusion height of active grains in the grinding wheel and the sizes and mass fractions of CeO_2 particles in the grinding zone on undeformed chip thickness (UCT). The results showed that the model of surface roughness was well consistent with the experiment. CeO_2 particle size significantly influenced the surface roughness than the mass fraction.

At the application of catalysts aspect, Chen et al. [51] proposed a new type of polishing slurry consisting of hydrogen peroxide and ferric chloride using to polish 304 stainless steel. It found that the material removal rate exceeds 700 nm/min and the surface roughness is below 5 nm after polishing using the optimized ratio of hydrogen peroxide and ferric chloride. In addition, the influence of the Fenton-like reaction between hydrogen peroxide and ferric chloride on chemical mechanical polishing 304 stainless steel was revealed. Wang et al. [52] studied the material removal mechanism of catalytic abrasive cluster on silicon carbide workpieces comparison of tribochemical mechanical polishing using Al_2O_3 abrasive, iron-based white corundum mixed abrasive and catalytic abrasive cluster. The experimental results showed that the catalytic abrasive cluster has better processability for 6H-SiC, and the material removal rate can reach to 42.928 nm/min, comparing with iron-based white corundum mixed abrasive and Al_2O_3 abrasive.

5 New machining method and prediction models

New processing methods are emerging to meet the goal of reducing emissions and carbon emissions. For example, Feng et al. [53] made a comprehensive and systematic review of the research progress in the field of powder preparation by external field–enabled atomization. The influence of powder properties on parts was analyzed from the perspective of additive manufacturing and the mechanism, equipment, and process parameters of external field–enabled atomization was also comprehensively summarized. At grinding method aspect, Hou et al. [54] investigated the grain refinement behaviors of stainless-steel materials subjecting to pre-stress grinding (PG) using a 3D FE-CA coupling method in conjunction with experimental comparisons. The reasons for the difficulty changes for obtaining dynamic recrystallization (DRX) transformation in deeper positions of ground surface layer were studied. It found that the acquisition of DRX on ground surface requires the utilization of aggressive grinding parameters, including larger depth of cut, slower feed speed, slightly higher wheel linear speed, and pre-stress in PG. Xu et al. [55] proposed a pre-stressed dry grinding technology, which was a combined machining including thermal–mechanical coupling effect. Based on experiment and surface topography modeling, the influence of pre-stressed force on surface quality and grit-workpiece kinematic interaction was revealed to verify the feasibility of this method. It found that the metallographic structure of the workpiece is stratified, which refines the crack formation and decreases the surface roughness with the increase of pre-stressed force. Kong et al. [56] discussed the correlation between the temperature and vibration signal and proposed a novel method to monitor the grinding temperature by the vibration signal analysis. They developed a simplified damped spring-mass model, moving heat flux model based on which simulation study on the generative vibration and temperature field under dry grinding. The results showed that the relative error was 7.2% by dry grinding of AISI1045. They also found that the correlation coefficient between the grinding temperature and the vibration signal under different cutting depths was 0.877, and under different feeding speeds, it was 0.917, demonstrating the consistency. Zou et al. [57] carried out an experiment with height measures and established an improved simulation model to predict the workpiece surface heights. The results showed that the predicted errors of the model are within 12%, high wheel speed is beneficial to improving convexity, and the reason for convexity is the wheel's angle displacement in the direction of the wheel's radius. At milling aspects, Wei et al. [58] studied the processing of large-sagittal MgF_2 aspheric optical components, analyzed the grinding tracks of two different grinding methods, and sought the best grinding method. It found that the rotational speed of the workpiece has the most significant effect on the surface roughness during pressed milling; when the grain size is 28 μm, the surface roughness Ra-parallel to and Ra-perpendicular to of face grinding were the smallest. Wang et al. [59] performed the high-speed face milling trials of Ti_2AlNb intermetallic alloys to investigate tool wear evolutions and wear mechanisms, specifically, tool wear morphologies, tool tip breakage, machined surface roughness, and cutting forces. Results indicated that high-speed face milling results in severe tool wears where adhesive wear and oxidation wear are the primary mechanisms of tool wear. It also found that tool life was limited to 228 s due to tool tip breakage resulted from coating delamination, cracking, and mechanical impact. Lin et al. [60] propose an adaptive fuzzy observer method to improve the Luenberger observer's adaptability and control robustness to nonlinear systems during drilling process. The experimental results showed that compared to traditional drilling technology, the adaptive fuzzy observer control method can cut costs, enhance machining accuracy, and compared with traditional driving and control methods, it can meet 8.7% energy saving requirement. At other methods aspects, Huang et al. [61] proposed a novel mixed spatial tooth profile modification method combining circumferential modification to improve the transmission accuracy of harmonic drive for the robot arms. The experimental results showed that the transmission error is 24.6 arc sec and the lost motion value is 0.16 arc min, the advantages of the mixed modification method are highlighted by comparing with the traditional method, and the radial error is reduced by 14.5%. Lu et al. [62] proposed a three-dimensional finite element simulation of the substrate temperature field to deposit diamond films on zirconia ceramic substrates. The simulation results indicated that the optimal parameters obtained are $h = 4$ mm, $d = 7$ mm, and $N = 7$. A typical microdiamond film, grain size of about 0.6 ~ 1 μm, deposition rate of about 0.625 μm/h, residual stress of about − 6.61 GPa, and full-width at half-maximum of 18 cm^{-1}, was obtained by experimental preparation.

The new prediction model improves the machining performance and provides useful guidance for industrial production. For example, Jin et al. [63] conducted a study on the surface roughness of the inner raceway of the outer ring of tapered roller bearings during grinding and established a prediction model for the grinding surface roughness. The influence law of grinding wheel linear speed, workpiece speed, and grinding depth on surface roughness was explored, and the surface roughness under high grinding wheel linear speed was predicted. The results showed that when the workpiece speed was 300 rpm and the grinding depth was 0.3 μm, the surface roughness decreased from 0.259 to 0.208 μm as the grinding wheel linear speed increased from 60 to 100 m/s. Yang et al. [64] proposed an improved NSGA-II multi-objective optimization algorithm, which reduced the carbon emissions during the grinding process while ensuring the same surface roughness and material removal rate, to better grinding aero-engine titanium alloy blades with the abrasive belt. The results showed that the optimization results of the algorithm have better diversity and uniformity and can find better non-dominated optimal solutions. Liu et al. [65] proposed an improved surface roughness prediction model, taking into consideration the influences of insert back cutting and stepover ratio. The experiment of face milling aerospace aluminum alloy 7075 is suggested to verify the improved model, and the Z-Map model is introduced for comparison. The results showed that the surface roughness is nonlinear with a feed per tooth and stepover ratio, a monotonic variation with corner radius, and a minor cutting-edge angle. In addition, the improved model reduces the prediction error of Ra from 11.2 to 4.2% in the non-overlapping compared with the Z-Map model and from 62.58 to 13.34% in the overlapping. Zheng et al. [66] proposed an analyzed model of machining-induced residual stress considering energy conversion in milling process to investigate the residual stress formation mechanism. The milling experimental results showed that errors between the predicted values and the experimental values are about 5% and 15%, respectively, and the conversion relationship between work and energy shows that the stored strain energy per unit time increases with the increase of the effective cutting work. Wu et al. [67] established a planar orthogonal cutting model by finite element method (FEM), and the cutting mechanism was studied based on the established model. Furthermore, it was proposed that the residual stress versus depth curve can be an exponential function and a linear superposition of high-order Gaussian functions. The experimental results showed that the final average error value of 20 sets of data is less than 5%, indicating that the model has high reliability. Huan et al. [68] presented an improved particle-reinforced titanium matrix composites simulation model based on image recognition and established a finite element model considering particle geometry and material damage behavior. The experimental results showed that the matrix plastic deformation and the tool extrusion influence the direction of particle fracture, and particles with a fracture angle of 45° are more likely to form gaps on the machined surface. She et al. [69] built a tool wear prediction model based on bidirectional long short-term memory neural network (BiLSTM) to address the online intelligent prediction of tool wear prediction based on indeterminate factor relationship. The results showed that the average prediction accuracy of the BiLSTM model reached 92.08%.

6 Non-traditional machining technologies

From the non-traditional machining technologies, it has unique advantages in machining aerospace materials. For example, Li et al. [70] compared and analyzed the relative discharge ratio, machining efficiency, electrode wear, and surface roughness using different control strategies (proportional–integral–derivative, modified servo control, and conventional control strategies) using a custom-made ball screw fluid electric discharge machining servo system, and obtained effective improvement compared with using traditional servo strategies in dry electric discharge machining. It found that the proportional derivative control strategy improved the effective discharge ratio by 40.4% and machining efficiency by 136.55% compared with conventional control strategy values. Zhao et al. [71] carried out conventional dry turning and electroplastically assisted dry turning with different electrical parameters to study the effects of electroplasticity on surface roughness, surface defects, tool wear, and chip morphology of W93NiFe alloy. The results showed that the electroplastically assisted dry turning process improved the surface quality of W93NiFe alloy. The surface roughness value decreased at the pulse voltage of 80 V, with the maximum reduction of 38.94%, and reduced the degree of machined surface defects in the material and tool wear compared with conventional dry turning. Qin et al. [72] proposed a novel electrochemical machining process for creating micropit arrays on such surfaces using a rolling device equipped with linear cathode and soft mask. Experimental tests of a 304 stainless-steel workpiece showed that under an applied voltage of 10.5 V and a workpiece rotating speed of 0.2 r/min, the diameter of micropit was 421.55 ± 18.75 μm, the depth was 70.2 ± 4 μm, the average etch factor (EF) was 1.16, and the roughness was 0.625 ± 0.205 μm, which suggested that the machined micropit arrays have high precision and uniformity. Sahu et al. [73] evaluated the sustainable machining under a cluster of 8 input process parameters, i.e., spark gap (Sg), gap voltage (Vg), pulse on time (Ton), pulse off time (Toff), peak current (Ip), servo feed (Sf), depth of cut (Dc), and difficulty index (Di) under multi-objective optimization (MOO) domain, by conducting on globally emerging Inconel 825 super alloy with a copper electrode in electrical discharge machining. It found that pulse off time was the chief significant parameter, and depth of cut was the second significant parameter for the machining performance. The optimal parametric setting was found as Sg2Vg3Ton1Toff1Ip3Sf1Dc1Di1. Liu and Fang [74] focused on the influence of discharge voltage, discharge current, and power pulse width on the surface morphology of the grinding wheel. The Electric spark dressing experiments on metal-bonded grinding wheel and the grinding experiments of SiC ceramics were carried out, using a single-factor method. It found that larger electrical parameters could improve the dressing efficiency, and they could also cause adverse effects on the grinding wheel surface such as abrasive shedding, looseness, and bond melting recasting.

7 Other sustainable production technologies

From the sustainability aspect, sustainable production is based on high quality, high efficiency, energy savings, and emission reduction. For instance, Kong et al. [75] provided an overview of the latest research progress in flexible graphene sensors. The main properties of graphene materials, including tensile strength, specific surface area, thermal conductivity, and electrical conductivity, were analyzed. A focus on innovations in graphene composites, regular microstructures, and emerging preparation methods was also reviewed. In addition, performance analysis of graphene-based multifunctional flexible sensors in the context of flexible systems was provided. Huang et al. [76] conducted an exhaustive literature review on magnetic bearings. They categorized various magnetic bearings and conducting an in-depth analysis of their properties and characteristics, focusing on their magnetic circuit structures. Subsequently, they delved into the working principles and performance of mathematical models for magnetic bearings with different configurations, outlining the modeling procedures and optimization approaches. Additionally, they highlighted the impact of control strategies on the performance of magnetic bearings. It found that modern control theory demonstrated a remarkable 50% improvement in position accuracy and adjustment time compared to traditional PID control. Kotteda et al. [77] studied the mechanical behavior of cast Al/GNP nanocomposites fabricated through stir casting, focused on the influence of dross on reinforcement infiltration into melt. It found that dross hinders the nanoreinforcement incorporation into the melt, i.e., 25 to 40% of introduced GNPs are entrapped in dross. Zhu et al. [78] fabricated 2219 aluminum alloy thin-walled tubes by multi-pass spinning process, and employed the heat treatments to optimize the mechanical properties of the spun tubes. The results showed that severe deformation during the spinning led to the formation of large number of nanoscale subgrains, which caused the decrease of work hardening rate, ultimate tensile strength, and fracture strain. Zhao et al. [79] designed an outdoor automated guided vehicle with an absorbent vibration system, and a seven-degrees-of-freedom model was established for this system. It found that the maximum predicted amplitude of sprung mass in the Simulink simulation model is 12.8 mm, and its prediction error is about 4.6%. The obstacle crossing simulation method based on Simulink designed saves about 28% of the working time of the designer compared with the traditional Adams simulation method.

From the papers published in this Special Issue, it found that the performance of enhanced manufacture technology based on emission reduction and carbon reduction has been obviously improved. For example, ultrasonic vibration–assisted technology can reduce cutting force by 5.1–64.4%, cutting temperature more than 37%, and surface roughness by 9.77 ~ 52.68% compared to the tradition machining; the coefficient of friction of nanofluids is reduced by 85% compared with dry conditions, which improves the tool life by 177–230% in hard milling. In addition, surface integrity can be predicted with an error of as little as 5% by new models. All of these demonstrates a good example of the great potential of sustainable manufacturing in carbon reduction. We hope they could provide new ideas and methods for researchers to machining processing based on emission reduction and carbon reduction. We also hope they will promote the continuous research on machining processing theory, tools, lubricant, clean cutting equipment, and key functional components and finally realize the application and revolution of machining processing technology in aerospace and other fields.

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Declarations

Competing interests The authors declare no competing interests.

Special issue information Achieving the global energy, sustainability, and decarbonization targets will rely on new breakthroughs, ideas, and concepts. International Journal of Advanced Manufacturing Technology contributes to the present discussion by proposing "Enhanced manufacture technology based on emission reduction and carbon reduction in cutting and grinding." Each special issue within this series aims to answer essential questions for the current state of the art: when looking all-in-once at the papers published in the different special issues, researchers and engineers may find answers, suggestions, and ideas to achieve significant technical achievements.

The studies may include, but are not limited to the following topics:
- Nanofluids minimum quantity lubrication.
- Cryogenic minimum quantity lubrication.
- Electrostatic atomization assisted minimum quantity lubrication.
- Material removal and damage mechanisms of composite materials machining with sustainable technology.
- Damage inhibition mechanism of difficult-to-machining material in green manufacturing.
- The advance application of sustainable manufacturing in biomedical field.
- Machining performance of high/ultra-high-speed grinding with usage of minimum quantity lubrication.
- Antifriction and antiwear behavior of (nano-enhanced) bio-lubricant in cutting zone.
- Heat transfer mechanism of (nano-enhanced) bio-lubricant in cutting zone.
- Atomization behavior of lubricant with assisted of electronic field.

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