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Editorial

Sustainable Manufacturing and Green Processing Methods

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Sustainable manufacturing and green processing methods have gained immense relevance over recent years due to pressing concerns over environmental degradation, resource scarcity, and industrial waste [1,2]. As industries transition to more eco-conscious practices, research plays an invaluable role in this context [3]. By investigating and proposing innovative strategies and frameworks, scientific studies have produced practical, evidence-based solutions in sustainable production [4]. Research efforts in this field are diverse and dynamic, encompassing advancements in energy-efficient machinery [5,6], low-impact materials, waste reduction technologies, and circular economy principles [7]. Furthermore, digital transformation technologies are beginning to redefine traditional processes by promoting resource-efficient practices [8–10]. This evolution is not merely a trend but a paradigm shift toward achieving long-term sustainability in industrial manufacturing [11].

This Special Issue of *Machines* presents five articles, each addressing unique aspects of sustainable manufacturing, from cooling technologies in machining to industrial metabolism frameworks. Together, these works highlight the evolving approaches to achieving sustainability in manufacturing, focusing on efficiency, resource optimization, and environmental preservation.

The first article, "Enhancing Machinability and Sustainability: The Effects of Hybrid MQL+CO_2 Cooling on the Drilling of AA7075T6 with TiO_2 and C-Reinforced Composites" [12], presents advanced cooling methods in machining aluminum alloy composites. By integrating Minimum Quantity Lubrication (MQL) and CO_2, the study reveals notable reductions in cutting forces, surface roughness, and energy consumption compared to dry cutting methods. This synergy of lubrication and cooling not only improves machinability but also contributes to substantial carbon emission reductions. This study demonstrates the importance of innovative cooling techniques for high-precision machining with minimized environmental impact.

In the second paper, "3D Printer Selection for the Sustainable Manufacturing Industry Using an Integrated Decision-Making Model Based on Dombi Operators in the Fermatean Fuzzy Environment" [13], the focus shifts to additive manufacturing (AM). As AM technologies become integral to sustainable manufacturing, selecting the right 3D printing technology is essential. This work presents a novel decision-making framework that uses Fermatean fuzzy sets to assist industries, particularly in sectors requiring complex, customizable production. The framework's emphasis on criteria like accuracy and quality offers a systematic approach to enhance the adoption of 3D printing technologies, fostering digital transformation and resource efficiency.

The third article, "Evaluation of Machining Variables on Machinability of Nickel Alloy Inconel 718 Using Coated Carbide Tools" [14], addresses the sustainability challenges of machining Inconel 718. Through detailed experimentation, this study assesses the impact of tool wear, surface roughness, and burr formation when using coated carbide tools under varied cutting conditions. The results reveal the importance of optimizing machining variables to reduce tool degradation and improve energy efficiency.

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Similarly, the fourth article, "Parametric Analysis of Tool Wear, Surface Roughness, and Energy Consumption during Turning of Inconel 718 under Dry, Wet, and MQL Conditions" [15], evaluates the role of cooling methods in the machining of nickel-based alloys. Using Taguchi experimental design, the study demonstrates that MQL cooling conditions optimize tool wear, energy consumption, and surface roughness more effectively than dry or wet conditions. This analysis highlights the significance of cooling techniques that align with green processing goals, offering engineers actionable strategies for waste reduction and resource conservation.

Finally, Industrial Metabolism: A Multilevel Characterization for Designing Sustainable Manufacturing Systems [16], presents a comprehensive approach to industrial sustainability through the concept of industrial metabolism. By modeling industrial activities as metabolic systems, the article draws analogies to natural ecosystems, emphasizing circularity and resource flow efficiency. This bio-inspired perspective on industrial metabolism proposes a multilevel framework applicable across regional, eco-industrial, and plant-specific scales, providing a robust basis for designing sustainable manufacturing systems that mimic ecological resilience and circularity.

Collectively, the articles in this Special Issue point out the multidisciplinary nature of sustainable manufacturing. By exploring innovative methodologies, ranging from advanced cooling in machining to systemic frameworks for industrial design, these contributions not only advance academic knowledge but also provide practical solutions for industries looking for the integration of sustainability into their production. This body of work illustrates that sustainable manufacturing is achievable through targeted technological advancements, optimized resource utilization, and systemic design principles. These contributions reinforce the vision of a sustainable, circular economy and accentuate the role of advanced manufacturing techniques in achieving that goal. As we look forward, these innovative methodologies provide a powerful foundation for more resilient, efficient, and sustainable manufacturing systems, integral to the future of industrial practices worldwide.

The editors extend their gratitude to the authors for their valuable contributions, to the reviewers whose expertise ensured the high quality of published articles, and to the journal's management team for their dedication and contributions to this Special Issue. They hope this collection inspires further research and action within both academia and industry to advance sustainable manufacturing practices.

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

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