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# Metal Additive Manufacturing and Its Post-Processing Techniques

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Metal additive manufacturing has made substantial progress in the advanced manufacturing sector with competitive advantages for the efficient production of high-quality products. The very nature of additive manufacturing processes enables the fabrication of a wide range of complex structures with near-net shape capabilities on various metals. Thus, this technology is highly attractive to specialized industries, such as the aerospace, automotive, medical, optics, and electronics industries. Additive manufacturing research is constantly evolving, with endless combinations of new materials and processes being tested, but a common challenge recognized in most of the literature is the inadequacy in the quality of the finishing, which calls for post-processing to achieve the desired geometrical accuracies, surface quality, and structural properties.

This Special Issue entitled "*Metal Additive Manufacturing and Its Post-Processing Techniques*" presents new findings on the state of the art in this field, through three reviews and seven original research articles covering an extensive range of systematic research, from the process workflow in the additive manufacturing process to the intermediary post-processes, such as heat treatment, and the finish and quality of the final products.

Metal additive manufacturing (e.g., selective laser melting and electron beam melting) is most associated with powder as raw materials but a lesser-known technology is liquid metal printing, which is based on commercial inkjet technology. Ansell [1] presented various types of printing techniques within this category of additive manufacturing, each of which are currently in different stages of technological readiness for commercial applications. Nonetheless, these additively manufactured metals will still require post-processing to deliver desirable properties.

These post-processes mostly consist of heat treatment and subtractive (material removal) processes, which can differ from the processing of conventional counterparts. Luna et al. [2] recognized the differences in microstructure of additively manufactured Inconel 625 nickel-based super alloy compared to conventionally casted counterparts, and presented a full investigation of the heat treatment schedule of the alloy and its microstructure and mechanical properties. These microstructural features can also result in anisotropies in the mechanical properties as reported by Meier et al. [3] on the Ti6Al4V titanium-based alloy, primarily related to building orientations. However, they also reported that heat treatment can potentially modify the anisotropy of the materials. Preferred heat-treatment schedules can also differ with additively manufactured metals, as presented by Jimenez et al. [4] in their paper on the metallurgical differences of heat-treated Ti6Al4V and the proposed heat-treatment combination for stress relief and beta-phase annealing compared with hot isostatic pressing, beta-solution, and over-ageing treatments.

A vast variety of material removal processes are available for the post-processing of additively manufactured metals, which include thermal-based processes and mechanical-based processes, as documented by Peng et al. [5] in a review on the state of the art. Most of these works comprise two separate manufacturing processes. The concept of hybrid manufacturing, which includes both the additive and subtractive components in an advanced machine tool, is relatively new but was successfully demonstrated by Sarafan et al. [6] as a feasible post-processing solution on maraging steel. Yet, optimal surface finishing requires a much more elaborate finishing process chain, which was explored by Zeidler et al. [7] with a conclusion on the adoption of a workflow comprising particle-blasting, vibratory-grinding, and plasma electrolytic polishing (PeP) to achieve a final quality of $Sa < 1$ μm on 316L stainless steel. An alternative to the optimization of surface finishing can even start from the additive manufacturing process to the post-process parameter selections with the aid of artificial neural networks. This was presented by Soler et al. [8] using a combination of selective laser melting, blasting, and electropolishing on Ti6Al4V.

While these topics on post-processing for additively manufactured metals are relatively more common, there are other perspectives on post-processes that are often neglected, such as the issue of powder removal from internal compartments recognized by Roberts et al. [9] in their work on a computational fluid dynamics model to simulate the removal of powder with vibratory assistance. Post-process selections also require considerations of the desirable properties of fabricated parts, such as friction and wear properties, as explained by Shah et al. [10] when considering key engineering materials (e.g., titanium, aluminum, and nickel-based alloys) and surface patterns. These traits can be processed by chemical, mechanical, and laser-based technologies.

The contents of the publications in this Special Issue may benefit research developments in metal additive manufacturing with an extensive overview of the current technological readiness of post processes and insightful considerations that are often neglected. The outlook of this technology is promising with respect to the advanced manufacturing of high-quality and high-precision products of the future.

**Conflicts of Interest:** The authors declare no conflict of interest.

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