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A review of approaches for additive manufacturing modeling of metallic parts using powder bed fusion, with a focus on minimizing computational costs and processing time.

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Additive Manufacturing (AM) has revolutionized various industries, offering the unique ability to produce complex geometries not achievable with traditional methods. Its competitive advantages, such as cost and lead time reductions, along with potential mass reduction through efficient designs, position AM as a promising solution in modern manufacturing. Guided by Computer-Aided Design (CAD) models, AM creates three-dimensional parts without the need for costly tools like dies or punches. Unlike subtractive manufacturing, AM uses a layered deposition approach, minimizing material waste and conserving energy. The layer-by-layer deposition involves complex thermal cycles, requiring a precise understanding of the relationships between processing parameters, final part properties, and material properties. Numerical simulations predict critical characteristics like distortion and residual strain, optimizing turnaround time and costs. However, accurately predicting the intricate multi-physics involved incurs substantial computational costs, limiting AM's practicality for certain applications. In the laser powder bed fusion (LPBF) process modeling for metals, a significant number of approaches have been developed to reduce the computational cost of numerical simulation. These approaches vary based on the extent of simplification applied to the model. For instance, the multi-scale approach comprehensively analyzes all physical phenomena in different stages. Although this method is highly precise, its implementation demands expensive computational resources, rendering it impractical for complex and large geometries. Conversely, the inherent strain approach incorporates simplifications through an initial calibration step, enabling the use of this model in simulations for large and complex parts. Furthermore, it is possible to optimize process parameters through a mesh refinement strategy, thereby reducing simulation time and computational costs. This review focuses on the LPBF process and explores the available approaches in the literature for optimizing computational resources. Given that each process parameter and material possesses characteristics that impact the manufacturing process, a comprehensive understanding of these approaches can assist in choosing the most suitable one. The discussion involves the extraction of relevant theoretical information from each approach and providing validated works from the literature as examples.