Chapter 2
Advancing Green Manufacturing With Sustainable Solutions for Advanced Materials

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ABSTRACT

This chapter touches upon the incorporation of such computational intelligence in the context of sustainable manufacturing of advanced materials from both present context and future prospect. The material creation framework depends on fundamental ideas, tools and techniques for producing sustainable materials and ecologically designed and assessed materials. The computational intelligence is studied and has shown significant importance in optimization of manufacturing process and also improvement of material properties of parts. It empirically provides pragmatic insights about the advantages and hurdle of the success of applications based on empirical studies of the success of the application on many industries. It ends by discussing economic, technologic and regulatory barriers to wide spread delivery and strategies to overcome these barriers and to continue innovation in sustainable manufacturing.

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INTRODUCTION

High performance or commercial application materials, such as high performance composites, biomaterials or nanomaterials are essential to contemporary industries (aerospace, automotive, electronics) with their outstanding properties of increased strength, reduced weight or increased durability. However, traditional manufacturing of these materials normally depends on non-renewable resources along with considerable energy consumption and generation of significant amount of waste thus creating different environmental issues. For instance, existing approaches, e.g., injection molding and machining, demand high levels of energy inputs, and produce great amounts of waste and emissions. Given the above issues, opportunities in green and sustainable manufacturing methodologies are increasing. And such methodologies aim to introduce these environmental impacts through reduced energy consumption, minimized waste output and increased renewable resource use that matches the workings of manufacturing to the greater global sustainability goals.

Novel or enhanced materials are advanced materials that have special properties superior to conventional materials. Technological innovations depend on these materials, and implications for different industries and societal progress are huge. Materials with new or improved functionalities over traditional materials for performance, such as physical, chemical, mechanical, and optical properties, are called advanced materials (Kennedy et al., 2019). Beyond traditional engineering, aerospace requires materials that can survive the most extreme environments high temperatures and mechanical stress all without compromising their functionality. The development of lightweight, durable, and high strength component materials for aircraft and spacecraft demands on advanced materials such as intermetallic γ-TiA*l* based alloys and nanocomposites (Bhat et al.,2021). Indeed, due to such use of advanced composite materials (similar to those used in Boeing 787 and Airbus A350), performance is improved significantly, and the weight is reduced as well, an advantage for fuel efficiency and airborne performance in aerospace applications (Sheikh et al., 2022).

More and more, smart materials with self-sensing and adaptive functions are incorporated in aerospace, featuring such unique capabilities as memory functions and self-adaptability to improve aerospace system performance and reliability. (Basheer, 2020) Industries that require high performance and reliability under extreme conditions cannot do without the use of advanced materials. In any industry, advanced composites, lightweight metals, and smart materials do indeed increase performance, reduce weight and improve fuel efficiency, and the aerospace industries benefit in particular. Development and application of these materials continue to improve. More often than not, traditional manufacturing processes like computer numerical control (CNC) milling consume higher amounts of energy than some additive manufacturing (AM) processes as far as life cycle of the product is concerned (Liu et al.,2023). The waste generation in traditional manufacturing process efficiency is inversely related to. The more efficient the process, the less waste will be produced and the less efficient the process, the more waste will be produced (Young et al., 2000). Much of what is produced in traditional manufacturing is material intensive, and involves large waste due to its lengthy production process, including machining parts that are often complex and require much machining (Jung et al., 2023).

Energy consumption in traditional manufacturing has a great environmental impact, leading to various unwanted effects related to its global warming potential (GWP), acidification potential (AP) and ozone depletion potential (ODP) (Karaeva et al., 2023). Overall environmental footprint of traditional manufacturing is greatly dependent on energy consumption in the manufacturing process, in which there are significant contributions to greenhouse gases and other pollutants (Ali et al., 2019). Specifically when