Chapter 1
Green and Sustainable Manufacturing of Advanced Materials: Progress and Prospects

P. Selvakumar
https://orcid.org/0000-0002-3650-4548
Nehru Institute of Technology, India

Siva Sankara Babu Chinka
https://orcid.org/0000-0002-1812-6125
Lakireddy Bali Reddy College of Engineering, Kakinada, India

M. Prabakaran
https://orcid.org/0009-0007-0025-5512
Karpaga Vinayaga College of Engineering and Technology, India

Santosh Kumar Nathsharma
https://orcid.org/0000-0003-3935-2938
Stewart Science College, India

J. Suhashini
https://orcid.org/0000-0003-2582-974X
GTN Arts College, India

Manjunath T. C
https://orcid.org/0000-0003-2545-9160
Rajarajeswari College of Engineering, India

ABSTRACT

Green manufacturing represents a pivotal shift in industrial practices, aimed at harmonizing economic growth with environmental stewardship. This chapter delves into the core principles and drivers behind green manufacturing, exploring how they collectively foster a more sustainable industrial ecosystem. At its essence, green manufacturing seeks to minimize the environmental impact of production processes while enhancing resource efficiency. The principles underpinning this approach are grounded in reducing waste, conserving energy, and utilizing environmentally friendly materials. By embedding these principles into the core of manufacturing practices, industries can significantly reduce their carbon footprint and contribute to broader sustainability goals.Central to green manufacturing is the efficient use of resources. This principle emphasizes minimizing the consumption of raw materials, energy, and water throughout the production process. Strategies such as process optimization, material substitution, and closed-loop systems are employed to achieve this goal.

DOI: 10.4018/979-8-3693-7974-5.ch001

INTRODUCTION TO GREEN MANUFACTURING: PRINCIPLES AND DRIVERS

Green manufacturing represents a pivotal shift in industrial practices, aimed at harmonizing economic growth with environmental stewardship. This chapter delves into the core principles and drivers behind green manufacturing, exploring how they collectively foster a more sustainable industrial ecosystem. At its essence, green manufacturing seeks to minimize the environmental impact of production processes while enhancing resource efficiency. The principles underpinning this approach are grounded in reducing waste, conserving energy, and utilizing environmentally friendly materials. By embedding these principles into the core of manufacturing practices, industries can significantly reduce their carbon footprint and contribute to broader sustainability goals.

Principles of Green Manufacturing

Resource Efficiency: Central to green manufacturing is the efficient use of resources. This principle emphasizes minimizing the consumption of raw materials, energy, and water throughout the production process. Strategies such as process optimization, material substitution, and closed-loop systems are employed to achieve this goal. For instance, recycling and reusing materials within the production cycle can substantially reduce the need for virgin resources.

Waste Minimization: Green manufacturing prioritizes the reduction of waste generated during production. This involves designing processes that produce fewer by-products and employing techniques to recycle or repurpose waste materials. Techniques such as lean manufacturing, which focuses on eliminating inefficiencies, and zero-waste strategies are integral to minimizing waste.

Pollution Prevention: Preventing pollution at its source rather than managing it after it has been created is a key principle of green manufacturing (Bai, C., et al., 2017). This approach involves redesigning products and processes to reduce the release of harmful substances into the environment. Techniques such as green chemistry, which focuses on creating safer chemical processes and products, play a significant role in this principle.

Drivers of Green Manufacturing

The transition to green manufacturing is driven by a confluence of regulatory, economic, and social factors (Jaffe, A. B., et al., 1997). Understanding these drivers provides insight into why industries are increasingly adopting sustainable practices.

Regulatory Pressures: Governments worldwide are implementing stricter environmental regulations to combat pollution and resource depletion. These regulations often mandate reductions in emissions, waste, and resource consumption, compelling manufacturers to adopt greener practices. Compliance with these regulations not only avoids penalties but also aligns companies with national and international sustainability goals.

Corporate Social Responsibility (CSR): Businesses are increasingly recognizing the importance of CSR in maintaining a positive public image and building trust with stakeholders. Green manufacturing aligns with CSR objectives by demonstrating a commitment to environmental stewardship and ethical practices. This alignment can enhance a company's reputation and foster stronger relationships with investors, customers, and the community.