

Exploring Sustainable Manufacturing: A Comprehensive Review of Literature and Practices



SantanKumar Chaurasiya and Gurraj Singh

1 Introduction

Manufacturing has been a crucial component of global economic growth for decades, but this progress has come at a significant cost to the environment. The traditional manufacturing practices have led to increased greenhouse gas emissions, depletion of natural resources, and waste generation. The need for a more sustainable approach to manufacturing has become more apparent in recent years, with climate change and environmental degradation posing a significant threat to our planet's future [1]. Sustainable manufacturing is an emerging field that focuses on reducing the environmental impact of manufacturing processes while maintaining economic growth. The concept of sustainable manufacturing involves integrating sustainability considerations into all aspects of the manufacturing process, from the sourcing of raw materials to the disposal of end products. The goal is to minimize the use of non-renewable resources, reduce waste generation, and promote environmentally friendly production practices [2, 3]. The concept of sustainable manufacturing has gained significant attention from various stakeholders, including governments, companies, and consumers. Sustainable manufacturing practices have become a critical business strategy for companies looking to reduce their environmental footprint, meet regulatory requirements, and improve their brand image. The trend toward sustainable manufacturing is also driven by consumer demand for environmentally friendly products and the desire to support socially responsible companies [4].

The principles of sustainable manufacturing are not only limited to environmental considerations but also encompass social and economic factors. The concept of sustainable manufacturing involves a balance between economic growth, social responsibility, and environmental sustainability. Sustainable manufacturing practices

S. Chaurasiya (✉) · G. Singh

Department of Industrial and Production Engineering, Dr B R Ambedkar National Institute of Technology, Jalandhar 144011, India

e-mail: chaurasiyasantan@gmail.com

must ensure that workers' rights are protected, and the local communities benefit from the manufacturing process [5]. The implementation of sustainable manufacturing practices involves a significant shift in the manufacturing paradigm, which requires the integration of sustainability considerations into all levels of decision-making. Sustainable manufacturing involves not only the adoption of new technologies and processes but also requires the development of new business models and supply chain management practices [6]. The importance of sustainable manufacturing is reflected in the United Nations' Sustainable Development Goals (SDGs). SDG 9, Industry, Innovation, and Infrastructure, specifically highlight the need for sustainable manufacturing practices. The goal is to promote inclusive and sustainable industrialization and foster innovation, while reducing the environmental impact of manufacturing processes [7].

The transition toward sustainable manufacturing requires a collaborative effort from all stakeholders, including companies, governments, non-governmental organizations (NGOs), and consumers. Companies can lead the way by implementing sustainable manufacturing practices that not only reduce their environmental footprint but also create value for their customers and stakeholders. Governments can play a significant role in promoting sustainable manufacturing practices by implementing policies and regulations that incentivize companies to adopt sustainable practices. NGOs and consumer groups can also raise awareness of sustainable manufacturing practices and encourage companies to adopt environmentally and socially responsible practices [8–10].

2 Sustainable Manufacturing Practice

Sustainable manufacturing practice refers to the implementation of manufacturing processes that minimize negative impacts on the environment, while also promoting economic development and social well-being. This involves reducing waste and pollution, conserving natural resources, adopting renewable energy sources, and using sustainable materials. Sustainable manufacturing also involves incorporating social and ethical considerations into the design and production process, such as fair labor practices, human rights, and community engagement. The article "Sustainable Manufacturing: Metrics, Standards, and Infrastructure" by Rachuri et al. [11] aim to provide an overview of the current state of sustainable manufacturing, including its metrics, standards, and infrastructure [11]. The article highlights the importance of measuring sustainability in manufacturing and provides an overview of the most commonly used metrics, including life cycle assessment (LCA) and carbon footprint. The authors also discuss the various standards that are used to evaluate sustainability, including ISO 14001 and the Global Reporting Initiative (GRI). The article further delves into the infrastructure necessary for sustainable manufacturing, including technology and workforce development [12]. The authors highlight the importance of technological advancements in improving the sustainability of manufacturing processes, such as the use of renewable energy and the development of

closed-loop manufacturing systems. They also discuss the need for a well-trained workforce with the necessary skills to implement sustainable manufacturing practices [13]. The article “Sustainable manufacturing: A bibliometric analysis” presents a bibliometric analysis of sustainable manufacturing research over a 30-year period from 1990 to 2019. The study aims to identify the intellectual structure, influential publications, and emerging trends in sustainable manufacturing research. The results show that sustainable manufacturing research has grown significantly in recent years, with a noticeable increase in publications since 2010. The intellectual structure of the field is diverse, with a wide range of topics and themes being studied, such as circular economy, ecodesign, and green supply chain management. The study identifies several influential publications and authors, as well as emerging research trends such as Industry 4.0 and sustainable production systems [14].

Machado et al. [15] focus on the role of innovation in promoting sustainable manufacturing practices. They highlight the importance of innovation in driving sustainable manufacturing practices and provide insights into the potential opportunities and challenges associated with promoting sustainability through innovation. The study is also adding valuable contribution to the field of sustainable manufacturing, and provides useful insights for policymakers, industry practitioners, and researchers [15]. The article by Miah & Ryan (2018) presents a study on the relationship between innovation and sustainability in manufacturing companies. The findings suggest that innovation positively impacts sustainability in manufacturing companies. They found that companies that adopted environmentally friendly technologies and practices were more likely to achieve sustainability goals. Additionally, they found that companies that emphasized social sustainability were more likely to achieve economic sustainability. Finally, they found that companies that invested in sustainable practices were more likely to be innovative.

The article Habidin et al. [16] provides a comprehensive review of sustainable manufacturing practices in the automotive industry, including energy efficiency, material efficiency, waste reduction, and supply chain sustainability. The authors argue that the automotive industry is a significant contributor to environmental degradation and social issues, and that sustainable manufacturing practices are critical for addressing these challenges [16]. The article by Kumar and Mani [17] presents a review of sustainability assessment methodologies used in manufacturing. The authors review a range of assessment methodologies used in the manufacturing sector, including life cycle assessment (LCA), sustainability performance measurement (SPM), sustainable value stream mapping (SVSM), and sustainability index (SI). They highlight the strengths and limitations of each methodology and discuss how they can be used in the manufacturing sector to support sustainable development. They also suggest that future research could focus on developing integrated assessment methodologies that consider the interactions between environmental, social, and economic factors [17]. The article by Bendig et al. [18] aims to provide a systematic review of the role of government policies and regulations in promoting sustainable manufacturing practices. The article starts with a brief introduction to sustainable manufacturing practices and the importance of government policies in promoting

them. The authors reviewed 53 research articles and identified several key government policies and regulations that have been successful in promoting sustainable manufacturing practices. These include ecolabeling and environmental standards, economic instruments, and regulatory frameworks. The article also discusses the challenges that governments face in implementing these policies and regulations, such as a lack of political will and resistance from industry stakeholders [18]. The article by Wasserbaur et al. [19] aims to provide a systematic review of the role of government policies and regulations in promoting sustainable manufacturing practices [19]. The article starts with a brief introduction to sustainable manufacturing practices and the importance of government policies in promoting them. The authors reviewed 53 research articles and identified several key government policies and regulations that have been successful in promoting sustainable manufacturing practices. These include ecolabeling and environmental standards, economic instruments, and regulatory frameworks. The article also discusses the challenges that governments face in implementing these policies and regulations, such as lack of political will and resistance from industry stakeholders [18].

The article “Circular Economy in Manufacturing: A Review” explores the concept of circular economy and its potential application in manufacturing. The authors highlight that the traditional linear model of manufacturing, which involves extracting resources, making products, using them, and then disposing of them, is no longer sustainable due to limited resources and environmental concerns. They argue that a circular economy, which emphasizes reducing waste and reusing resources, can provide a more sustainable approach to manufacturing [20].

3 Sustainable Supply Chain Management (SSCM) and Manufacturing Practice in Business Performance

The article reviews the literature on sustainable manufacturing practices (SMPs) and their impact on business performance. The authors conducted a systematic literature review to identify and analyze the existing literature on SMPs and business performance. They identified 84 studies published between 2000 and 2018 and analyzed them using a thematic approach. The review finds that SMPs have a positive impact on business performance, including economic, environmental, and social performance. The economic benefits include cost savings, increased revenue, and improved competitiveness. The environmental benefits include reduced energy consumption, waste reduction, and decreased emissions. The social benefits include improved health and safety, employee satisfaction, and community engagement [21]. The article “Building Information Modelling for Sustainable Construction” by Gao et al. provides an overview of Building Information Modelling (BIM) technology and its role in sustainable construction practices. The authors highlight the potential

of BIM technology to improve the sustainability of the construction industry by facilitating more efficient use of resources, reducing waste and emissions, and enhancing collaboration and communication among project stakeholders [22].

The article titled “Enhancing sustainability in supply chains through inter-firm collaborations: An empirical investigation” aims to explore the relationship between inter-firm collaboration and sustainability in supply chains. The study was conducted through a survey of 169 Indian manufacturing firms, and the data was analyzed using Structural Equation Modelling (SEM). The study highlights the importance of collaboration in achieving sustainability goals and emphasizes the need for policymakers to encourage such collaboration through appropriate policies and incentives. Overall, the study contributes to the literature on sustainable supply chains by providing insights into the role of inter-firm collaboration in enhancing sustainability [23].

In this article, Bovea and Pérez-Belis review the literature on models for sustainable supply chain management (SSCM). They provide an overview of various approaches to SSCM, such as life cycle assessment, ecodesign, and closed-loop supply chains, and discuss their strengths and weaknesses. The authors also examine the role of stakeholders in SSCM and the importance of collaboration and information sharing among supply chain partners. The article concludes with a discussion of future research directions in SSCM, including the need for more empirical research, the development of integrated SSCM models, and the use of emerging technologies such as blockchain and the Internet of Things. The authors also emphasize the importance of considering social sustainability issues in addition to environmental concerns, and the need for SSCM models to be adapted to the specific context and goals of each supply chain [24]. In another study provided by Panigrahi et al. [25] a comprehensive review of the existing literature on sustainable supply chain management (SSCM) and identifies areas for future research. The article highlights the need for a more integrated and collaborative approach to SSCM, involving all stakeholders in the supply chain. The authors suggest that future research should focus on developing frameworks and tools to enable organizations to implement SSCM effectively. They also call for more empirical studies to evaluate the impact of SSCM on organizational performance and sustainability outcomes [25].

4 Sustainable Manufacturing Practice: Challenges and Future Trend

The article “Sustainable manufacturing education and training: A review of current practices and future trends” presented by Domadi MK [26], authors conclude that sustainable manufacturing education and training should be integrated into existing engineering and business curricula to ensure that graduates have the necessary knowledge and skills to address sustainability challenges. They also recommend the development of new programs and the use of innovative teaching methods, such as

experiential learning and industry collaborations. Additionally, the authors emphasize the importance of lifelong learning and professional development to ensure that professionals stay up to date with the latest sustainable manufacturing practices [26]. The article “Sustainable Production: A Critical Review” by Colicchia et al. examines the state of research on sustainable production, identifying gaps and opportunities for future research. They suggest that future research should aim to develop new models and frameworks that can better capture the complex interactions between these different factors. Additionally, the authors highlight the importance of engaging stakeholders and creating new business models that enable sustainable production practices to be integrated into the broader value chain [27]. In this article, the authors provide a comprehensive review of the literature on sustainable manufacturing systems (SMS). The study examines research trends and identifies gaps in the field, providing a roadmap for future research. The authors highlight the importance of sustainable manufacturing systems in achieving environmental sustainability, economic development, and social well-being. The article first presents the evolution of sustainable manufacturing and then discusses the key elements of SMS such as design for sustainability, green supply chain management, lean manufacturing, and life cycle assessment. The article also discusses various drivers and barriers of SMS implementation and explores the role of government policies and regulations in promoting sustainable manufacturing [28]. The article by Ocampo and Clark [29] presents a framework for developing a sustainable manufacturing and operations strategy. The framework provides a comprehensive perspective that considers environmental, social, and economic factors, as well as stakeholder engagement and collaboration. The article concludes by highlighting the need for further research to address the challenges associated with sustainable manufacturing modeling and optimization. The authors argue that there is a need for more integrated approaches that can capture the interrelationships between product, process, and system levels, and that can account for the complex trade-offs between different sustainability objectives [29].

The article by Jayal et al. [30] presents a comprehensive review of the literature on sustainable manufacturing, and highlights some of the key research trends and directions in the field. The authors argue that there is a need for more integrated approaches that can capture the interrelationships between product, process, and system levels, and that can account for the complex trade-offs between different sustainability objectives [30]. The article “Integrating sustainability into operations management research and practice: Recent progress and future directions” by Wu, Cegielski, and Hazen aims to examine the recent progress in integrating sustainability into operations management (OM) research and practice and provide future research directions. The study identified that sustainability is becoming increasingly integrated into OM research and practice, with a growing number of studies investigating the linkages between sustainability and OM. The review also identified gaps in current research, such as a lack of focus on the impact of sustainable practices on OM performance and a lack of attention given to the trade-offs between sustainability and other OM objectives. The authors suggest future research should focus on measuring the impact of sustainable practices on OM performance

and identify trade-offs between sustainability and other OM objectives [31]. The article “Achieving sustainability through small business initiatives: Exploring the role of information technology” by Luederitz et al. [32] reviews the literature on how small businesses can achieve sustainability through the adoption of information technology (IT) initiatives. The authors identified six IT initiatives that can promote sustainability in small businesses: cloud computing, social media, big data analytics, mobile devices, radio frequency identification (RFID), and green IT. The authors then discuss the mechanisms through which these initiatives can promote sustainability, including reducing energy consumption, promoting waste reduction, and improving supply chain management [32].

We discussed a comprehensive review of the literature on sustainable manufacturing and operations management, identifying gaps and opportunities for future research. The authors highlight the importance of integrating sustainability into existing curricula, developing new programs, and using innovative teaching methods. They also emphasize the need for more integrated approaches that can capture the interrelationships between product, process, and system levels, and account for the complex trade-offs between different sustainability objectives. Additionally, the articles discuss the role of government policies, stakeholder engagement, and the adoption of information technology initiatives in promoting sustainable practices.

5 Conclusion

Sustainable manufacturing is a critical component of the global effort to promote environmental sustainability, social responsibility, and economic growth. The field of sustainable manufacturing has gained significant attention from various stakeholders, including governments, companies, and consumers. Sustainable manufacturing practices involve integrating sustainability considerations into all aspects of the manufacturing process, from the sourcing of raw materials to the disposal of end products.

The implementation of sustainable manufacturing practices requires a significant shift in the manufacturing paradigm, which requires the integration of sustainability considerations into all levels of decision-making. The transition toward sustainable manufacturing requires a collaborative effort from all stakeholders, including companies, governments, NGOs, and consumers. The importance of sustainable manufacturing is reflected in the United Nations’ Sustainable Development Goals, which specifically highlight the need for sustainable manufacturing practices.

Overall, sustainable manufacturing practices have become a critical business strategy for companies looking to reduce their environmental footprint, meet regulatory requirements, and improve their brand image. Sustainable manufacturing practices not only reduce the environmental impact of manufacturing processes but also create value for customers and stakeholders. The transition toward sustainable manufacturing requires a collective effort from all stakeholders, and continued research and

innovation in this area can have a significant impact on environmental sustainability and social responsibility.

6 Future Scope

The future scope of sustainable manufacturing is promising, with many opportunities for improvement and growth. Companies that prioritize sustainable manufacturing practices will be better positioned to meet the evolving demands of consumers and regulators and contribute to a more sustainable future.

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