IJFANS INTERNATIONAL JOURNAL OF FOOD AND NUTRITIONAL SCIENCES
ISSN PRINT 2319 1775 Online 2320 7876
Research Paper , Journal UGC CARE Listed (Group-I) Volume 15 , Issue 02, 2026

# SMART MANUFACTURING WITH CAD/CAM: INTEGRATING AUTOMATION AND OPTIMIZING PRODUCT LIFECYCLE MANAGEMENT

**Sejal S Bagad[1], Dr. Dipak K Dond[2]**

[1]ME (Master in Engineering) Mechanical Engineering , MET's Bhujbal Knowledge city, Institute of Engineering, Adgaon, Nashik-422003
Email- sejalbagad@gmail.com
ORCID: 0009-0001-6475-0762
[2]MET's Bhujbal, Knowledge city,Institute of Engineering, Adgaon, Nashik-422003
Email- dipak_ioe@bkc.met.edu, ORCID: 0000-0002-7973-0684

## Abstract

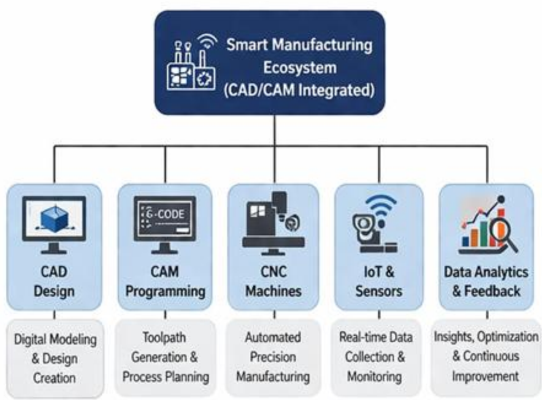
Smart manufacturing uses modern technology like CAD and CAM. Improve product quality, save expenses, and boost efficiency using these technologies. This article examines how CAD/CAM technologies optimise Product Lifecycle Management. Intelligent manufacturing enables real-time decision-making, flexible production, and sustainability. This is done by connecting design, production, and management in manufacturing. The study discusses CAD/CAM-based automation's pros, cons, and future in modern production.

**Keywords:** Smart manufacturing, CAD/CAM, automation, product lifecycle management, digital manufacturing.

## INTRODUCTION

The industrial industry is undergoing a massive transformation due to digital technology and automation. Computer-based technologies, the internet of things, and artificial intelligence provide adaptive production methods in smart manufacturing. Computer-aided design and computer-aided manufacturing (CAD/CAM) is important because it links product design with industrial implementation. Engineers use CAD software to create realistic digital models. Computer-aided manufacturing (CAM) software automates machining from these designs. CAD and CAM can be used together to integrate the entire product lifecycle, from concept to production and maintenance.

Figure 1: Smart Manufacturing Ecosystem Integrating CAD/CAM



## Smart Manufacturing and Its Importance

Smart manufacturing emphasises efficient, adaptable, and customer-responsive production processes using cutting-edge digital technologies and automation tools. Data-driven and adaptive production processes can quickly respond to changing market demands, tailored orders, and growing consumer preferences. Smart manufacturing reduces lead times, waste, and increases product quality. This is achieved by integrating digital technologies into production.

**KEY FEATURES INCLUDE:**

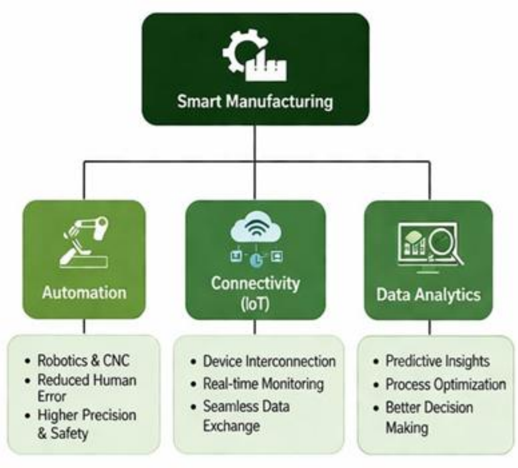



**Figure 1: key feature of smart manufacturing**

**Automation:** Automation is key to intelligent manufacturing. Artificial intelligence-driven industrial systems, advanced robots, and CNC equipment can perform complex or repetitive tasks precisely, reducing human errors and operating risks. Cobots, collaborative robots, can work alongside humans on manufacturing lines to improve productivity and safety. Automation allows real-time manufacturing modifications based on sensor feedback, ensuring quality consistency.

**Connectivity:** The Internet of Things (IoT) connects devices, sensors, and equipment to collect and distribute data in real time. This link allows producers to monitor supply chain conditions, equipment health, and production progress. For instance, an internet-connected CNC machine can transmit its operational status, allowing engineers to discover irregularities and avoid downtime.

**Data-Driven Operations:** Smart manufacturing emphasises data analytics and predictive application technologies for efficiency. Predictive maintenance reduces unnecessary downtime by using historical and real-time data to predict equipment breakdown. Analytics can improve demand forecasts, inventory optimisation, and process improvements. Manufacturers may organise resources, improve energy use, and reduce costs while maintaining high-quality outputs using this information.

Smart manufacturing solutions boost operational efficiency and global competitiveness. Digital design and prototyping boost creativity, reduce material waste and energy usage, and

ISSN PRINT 2319 1775 Online 2320 7876
 Journal UGC CARE Listed (Group-I) Volume 15 , Issue 02, 2026

allow organisations to quickly adapt to changing client needs. Considering these benefits, smart manufacturing is poised to transform modern industry.

**Role of CAD/CAM in Smart Manufacturing**

The cornerstone of smart manufacturing is comprised of computer-aided design and computer-aided manufacturing (CAD/CAM) systems. These systems operate by establishing a digital connection that is seamless between the product design process and the production methods. The use of computer-aided design (CAD) enables engineers to generate precise digital models, conduct simulations, and validate designs before the real manufacturing of the product. This is all accomplished before the product is ever manufactured. As a result, the amount of errors that arise is decreased, and there is no longer a requirement for costly prototypes. Afterwards, the designs are converted into particular machine instructions through the use of computer-aided manufacturing (CAM). This process makes it possible for automated machinery, such as CNC machines and robotics, to carry out production with a high degree of accuracy and consistency. Through this connection, production processes are guaranteed to be directly led by design intent, which in turn helps to reduce discrepancies and streamline operational efficiencies.

Employing computer-aided design and computer-aided manufacturing (CAD/CAM) in automated manufacturing systems enables organisations to simulate production situations, optimise machining processes, and anticipate potential problems before they occur. CAD/CAM is also known as computer-aided manufacturing. As a direct result of this, the cycle of product production is greatly shortened, enhancements are made to quality control, and operating expenses are reduced. Additionally, computer-aided design and computer-aided manufacturing (CAD/CAM) makes it feasible to establish adaptive manufacturing, which enables changes in design to be immediately integrated in production without significant downtime. This is made possible by the combination of these two technologies. This helps to support the goals of making smart manufacturing more efficient, flexible, and responsive, which are all essential components of smart manufacturing.

**INTEGRATION WITH AUTOMATION**

Digitally linking design data to automated gear lets manufacturers create a coherent system that maximises productivity and meets performance standards. This is achievable because the system meets high performance standards.

**Seamless Digital Instructions:** CAD/CAM technology convert drawings into machine-readable instructions. CNC machines can use CAD-generated tool paths and operating sequences. The machine no longer needs manual interpretation. This reduces human errors and ensures output consistency. This smooth transition from design to implementation speeds up production, reducing errors.

**Adaptive Production:** Automated manufacturing systems are possible using CAD/CAM and automation. Sensor-equipped machines can monitor temperature, vibration, and material anomalies in real time and change their operations accordingly. This dynamic input ensures industrial processes remain efficient and sensitive to unexpected variations, enabling flexible production and customisable outputs.

**Enhanced Quality Control:** The implementation of automatic feedback loops improves quality assurance significantly. Comparing the finished product to the digital design helps CAD/CAM-integrated systems find production errors. This comparison is needed to find any errors. Early deviation identification reduces scrap rates, costs, and ensures high-quality final goods. All benefits can be achieved concurrently.

The combination of computer-aided design and computer-aided manufacturing (CAD/CAM) with automation results in the creation of a closed-loop system that brings together design, production, and monitoring. Productivity is increased and errors are reduced when there is harmony in the workflow. Manufacturing companies are able to develop production systems that are more intelligent and responsive thanks to smart manufacturing software.

## OPTIMIZING PRODUCT LIFECYCLE MANAGEMENT (PLM)

PLM is a comprehensive strategy that regulates a product from conception to disposal. PLM is product lifecycle management. CAD/CAM and PLM can be integrated to create a digital backbone that integrates the entire product lifecycle. This ensures no information disruptions, better decisions, and enhanced operational efficiency.

**Design Phase:** Computer-aided design (CAD) technologies enable engineers, designers, and stakeholders to collaborate on design. These techniques provide precise digital modelling and version control. Virtual prototyping lets manufacturers test product performance and find design issues before manufacturing. This helps producers make product decisions. Thus, development is shortened and expensive revisions are no longer needed.

**Manufacturing Phase:** Computer-aided manufacturing (CAM) systems convert design models into production instructions during manufacture. This is done by systems. This helps plan processes, schedule machines, and allocate resources. Computer-aided manufacturing (CAM) and product lifecycle management (PLM) systems allow organisations to immediately monitor production, optimise productivity, and alter operations. This ensures the production process meets quality and design standards.

**Post-Production Phase**: Professional Life Cycle Management (PLM) oversees product maintenance, updates, and recycling after manufacture. CAD and CAM enable the acquisition of accurate product data for maintenance planning, ongoing improvements, and sustainable disposal strategies, which reduce the positive impact on the environment.

Manufacturers may reduce product launch time, cost, and sustainability by integrating CAD/CAM with PLM. Implementing a comprehensive strategy links all product lifecycle stages. It makes industrial processes smarter and more responsive and promotes innovation and competitiveness over time.

## CHALLENGES IN IMPLEMENTATION

The integration of CAD/CAM into smart manufacturing presents several obstacles to its proper use. Companies interested in using current manufacturing technologies must be aware of the challenges.

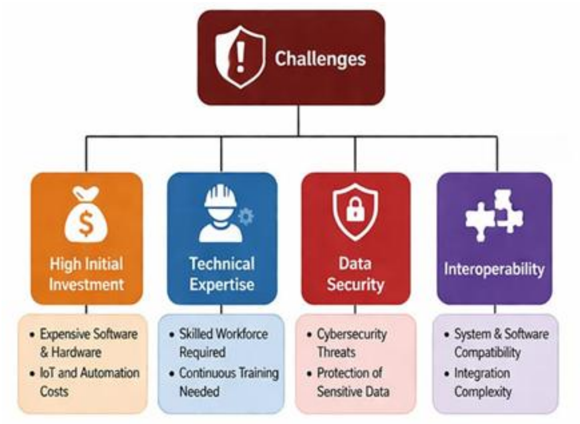



Figure 2 : Challenges in implementing CAD/CAM system

**High Initial Investment:** CAD/CAM systems and automation technologies are expensive to implement. Expenses include software licensing, machinery upgrades, Internet of Things devices, and personnel training. These initial investments may be a hurdle for small and medium-sized enterprises, slowing uptake and limiting reach. This would narrow adoption.

**Technical Expertise:** CAD/CAM systems and automated machines require highly skilled workers to operate, program, and maintain. This workforce is crucial to intelligent manufacturing. Insufficient technology adoption and operational inefficiencies may be due to a skills gap. This emphasises ongoing training and skill improvement.

**Data Security:** The Internet of Things and cloud platforms have boosted connection, making manufacturing processes vulnerable to cybersecurity threats. Unauthorised people can access, corrupt, or steal key design data, production specifications, and operational knowledge. This is possible. Effective cybersecurity and digital infrastructure protection are essential to mitigate these threats.

**Interoperability:** A fully integrated manufacturing environment requires CAD/CAM software, automation hardware, and PLM systems that interact well. Technology solutions must be carefully selected and standardised to avoid operational bottlenecks and efficiency losses. Incompatibilities between platforms, software versions, or equipment may cause these issues.

Strategic planning, secure and interoperable digital infrastructure investments, and worker training are essential to tackling these difficulties. Businesses that proactively overcome these challenges can fully exploit the benefits of CAD/CAM-enabled smart manufacturing. This is because these organisations can completely reap the rewards.

**FUTURE TRENDS IN SMART MANUFACTURING WITH CAD/CAM**

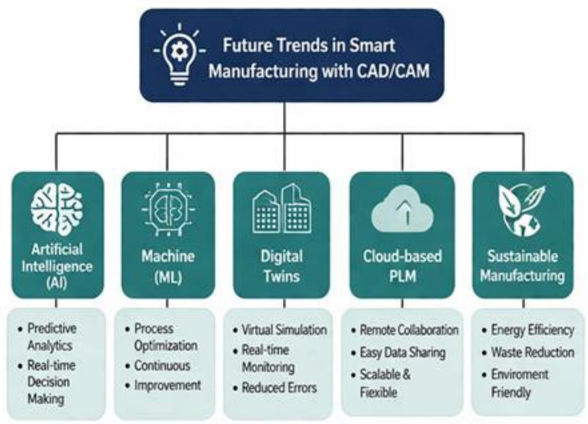



**Figure 3: Future Trends In Smart Manufacturing With CAD/CAM**

In the future of smart manufacturing, artificial intelligence (AI) and machine learning (ML) are going to play an increasingly significant role. The implementation of these technologies enables the execution of predictive analytics, the establishment of decisions in real time, and the optimisation of production procedures. Systems that are powered by artificial intelligence are able to predict when equipment may break, improve machining pathways, and enhance overall operational efficiency, which ultimately results in a reduction in both downtime and expenses. Increasing productivity across the entirety of the manufacturing lifecycle is something that manufacturers may accomplish by making use of the data that is gathered from sensors and devices that are connected to the Internet of Things. Because of this, manufacturers are able to make decisions that are better informed and respond more swiftly to the evolving demands of the market.

One more significant innovation that has been implemented in the manufacturing sector is the utilisation of digital twins, which are virtual replicas of genuine production systems that are updated in real time. With the assistance of digital twins, engineers and management are able to recreate production scenarios, test design changes, and monitor performance without creating any disturbance to actual operations. This is all accomplished without causing any real-world disruptions. This virtual representation makes it possible to promote continuous improvement in manufacturing processes, minimise the amount of errors that occur, and increase predictive maintenance. All of these goals can be accomplished. The combination of computer-aided design and computer-aided manufacturing (CAD/CAM) models with digital twins enables manufacturers to develop production environments that are highly responsive and adaptive, thereby boosting both accuracy and efficiency.

The future landscape is being influenced by manufacturing techniques that are environmentally friendly as well as systems for Product Lifecycle Management (PLM) that are housed in the cloud. Product lifecycle management (PLM) that is hosted in the cloud makes it simpler to collaborate and develop remotely. It also simplifies the process of exchanging data and enhances the sense of coordination among teams located all over the world. In addition, the combination of computer-aided design (CAD) and computer-aided manufacturing (CAM) helps in the implementation of sustainable practices by increasing the efficiency with which materials are utilised, reducing the amount of energy that is consumed, and limiting waste. These new technologies are working together to pave the way for the production of ecosystems that are capable of adapting to their surroundings, are efficient, and are environmentally responsible. When it comes to dealing with the challenges that will be encountered in the future, these ecosystems will be thoroughly prepared.

## CONCLUSION

The revolution of modern production is being driven by the implementation of computer-aided design and manufacturing (CAD/CAM) systems, additionally known as automation. It is possible to connect the processes of design, production, and product lifecycle management (PLM) in order to obtain higher levels of efficiency, improved quality, and reduced costs. The introduction of cutting-edge digital tools places businesses in a position to acquire a competitive advantage, respond rapidly to the demands of the market, and maintain production processes that are ecologically responsible. This is the case despite the fact that there are difficulties that need to be addressed. It is anticipated that developments in artificial intelligence (AI), digital twins, and cloud computing would significantly enhance the effectiveness of manufacturing operations in the years to come.

## REFERENCES:

1. Anbalagan, A. (2021). An IoT based industry 4.0 architecture for integration of design and manufacturing systems. Materials Today: Proceedings, 46, 7135–7142. https://doi.org/10.1016/j.matpr.2020.11.196
2. Holligan, C. (2017). Product lifecycle management and digital manufacturing technologies in the era of cloud computing. 2017 International Conference on Engineering, Technology and Innovation (ICE/ITMC). https://doi.org/10.1109/ice.2017.8279980
3. Marko Simonič, & Iztok Palčič. (2025). Advancing Intelligent Toolpath Generation: A Systematic Review of CAD–CAM Integration in Industry 4.0 and 5.0. Strojniški Vestnik – Journal of Mechanical Engineering, 71(9-10), 328–336. https://doi.org/10.5545/sv-jme.2025.1370
4. Mourtzis, D. (2022, January 1). Chapter 2 - Digital Manufacturing: the evolution of traditional manufacturing toward an automated and interoperable Smart Manufacturing Ecosystem. ScienceDirect; Elsevier. https://www.sciencedirect.com/science/article/pii/B9780323916141000022
5. Ye, L. (2024). Design and manufacturing of mechanical parts based on CAD and CAM technology. Engineering Research Express. https://doi.org/10.1088/2631-8695/ad8056