The American Journal of Engineering and Technology
ISSN 2689-0984 | Open Access

TYPE Original Research
PAGE NO. 6-11
DOI 10.37547/tajet/Volume07Issue02-02

Check for updates

Using cad systems for automating the design and prototyping process

Brijesh Pandya

Design Engineer, Forest Lake Minnesota US

OPEN ACCESS

SUBMITED 01 December 2024
ACCEPTED 05 January 2025
PUBLISHED 06 February 2025
VOLUME Vol.07 Issue02 2025

CITATION

Brijesh Pandya. (2025). Using cad systems for automating the design and prototyping process. The American Journal of Engineering and Technology, 7(02), 6–11. https://doi.org/10.37547/tajet/Volume07Issue02-02

Abstract: This study examines the potential application of CAD systems to optimize design and prototyping processes in engineering and manufacturing. The objective is to conduct a comprehensive analysis of the potential of these systems to enhance the efficiency of development and prototyping. Particular attention is given to their functional capabilities, including integration with other technological platforms, the creation of digital prototypes, and automatic error detection at early development stages. The methodological approach involves analyzing scientific studies available on the Internet.

The results of the reviewed studies confirm that the implementation of CAD systems reduces development time and improves product quality. The use of 3D modeling and process simulation tools enables the identification of defects at initial stages, preventing their propagation during production.

The practical significance lies in the fact that the proposed approaches may be of interest to engineers, designers, and project managers seeking to increase development efficiency, reduce costs, and improve production processes at all stages of the product life cycle—from concept creation to prototype manufacturing.

Thus, the use of CAD systems for automating design and prototyping serves as a tool for achieving a high level of productivity and design precision.

Keywords: CAD systems, design automation, prototyping, integration, CAM, CAE, digital prototype, 3D modeling, development efficiency, productivity.

Introduction: CAD systems enable the creation of precise digital models, accelerating development processes, reducing costs, and improving product quality. However, many enterprises face challenges in integrating such systems into existing processes, emphasizing the importance of further analysis of their application.

The relevance of this topic lies in the fact that the use of CAD technologies accelerates development and increases accuracy at all stages of the product life cycle, from design to testing. However, some organizations do not fully utilize the potential of these technologies, highlighting opportunities for further advancements.

The novelty of the study lies in analyzing the impact of CAD systems on design and prototyping processes, comparing the capabilities of various software solutions across industries. The work addresses both theoretical and practical aspects of implementing such technologies, including their interaction with other systems for production process management, analysis, and calculations.

The objective is to conduct a comprehensive analysis of the potential of CAD systems to enhance the efficiency of development and prototyping. Particular attention is given to the functional capabilities of these systems, including integration with other technological platforms, the creation of digital prototypes, and automatic error detection at early development stages.

The study examines methods of integrating CAD systems with other automated systems, with a focus on identifying factors that determine the successful implementation of CAD technologies in enterprises.

The practical significance of the study lies in its applicability for engineers, designers, and enterprise managers to optimize design processes, improve development quality, and reduce costs associated with errors and necessary revisions.

METHODS

The literature on the use of CAD systems highlights various approaches that address different aspects of applying these technologies in design and production processes.

One area of focus is the automation of creating and evaluating 3D models. For example, Eltaief A. et al. [1] proposed an automated system for evaluating CAD models designed for mechanical engineering students. This method accelerates feedback and improves the quality of models and the efficiency of the learning process. A similar approach is described in the work of Favi C. et al. [2], which explores the automation of creating 3D models and drawings, as well as the increased speed and adherence to production standards when using CAD systems.

Another aspect is the use of CAD systems in prototyping and manufacturing. The study by Crăcun R. S., Moroșanu G. A., Teodor V. G. [3] discusses the application of CAD for prototyping using 3D printing, enhancing prototyping accuracy during the production of unique items where control at each stage is crucial.

Within the context of digital transformation, there is also a shift from individual prototyping to mass production. In the work by Peng F. [6], a framework is proposed for optimizing CAD models and G-codes used in industrial 3D printing, facilitating the transition from prototypes to series production.

The use of CAD systems in specialized industries, such as furniture manufacturing, has also been explored in research. Manavis A. et al. [4] describe the application of CAD for digital customization in furniture design and production. The authors emphasize how automation at all stages, from design to manufacturing, can improve accuracy and accelerate order fulfillment.

The study by Buric M., Brcic M., Skec S. [5] examines a tool for the automatic generation of 2D drawings from 3D models, significantly simplifying the creation of technical documentation.

The source [7], available on the website www.imarcgroup.com , provided statistical data on the use of CAD systems.

An analysis of the reviewed works highlights several directions: automation of design and prototyping, transitioning from prototyping to mass production, and the application of CAD systems in various industries. However, scientific articles insufficiently address the integration of production stages such as quality control, logistics, and the challenges of sustainability and long-term operation of CAD-created models.

The methodological approach is based on an analysis of scientific works available online.

RESULTS AND DISCUSSION

The market for 3D CAD software is expanding due to technological advancements, increased adoption across various industries, and growing demand for precision in design and manufacturing. Key factors driving this growth include the rising use of 3D printing, which heavily relies on CAD (Computer-Aided Design) systems for accurate prototype creation, and the rapid digitalization of industries such as automotive, aerospace, and construction. Additionally, the demand for enhanced visualization, virtual testing, and simulation has encouraged the adoption of 3D CAD tools.

The integration of cloud-based CAD solutions offers flexibility by enabling remote collaboration and reducing operational costs. For example, in August 2024, GstarCAD announced the launch of GstarCAD 365, a cloud-based, lightweight, cross-platform CAD solution for real-time collaboration. GstarCAD 365 simplifies multi-user and cross-platform collaboration, allowing users to view, create, and manage drawings from anywhere [7]. Below, Figure 1 illustrates trends in the development of CAD systems.

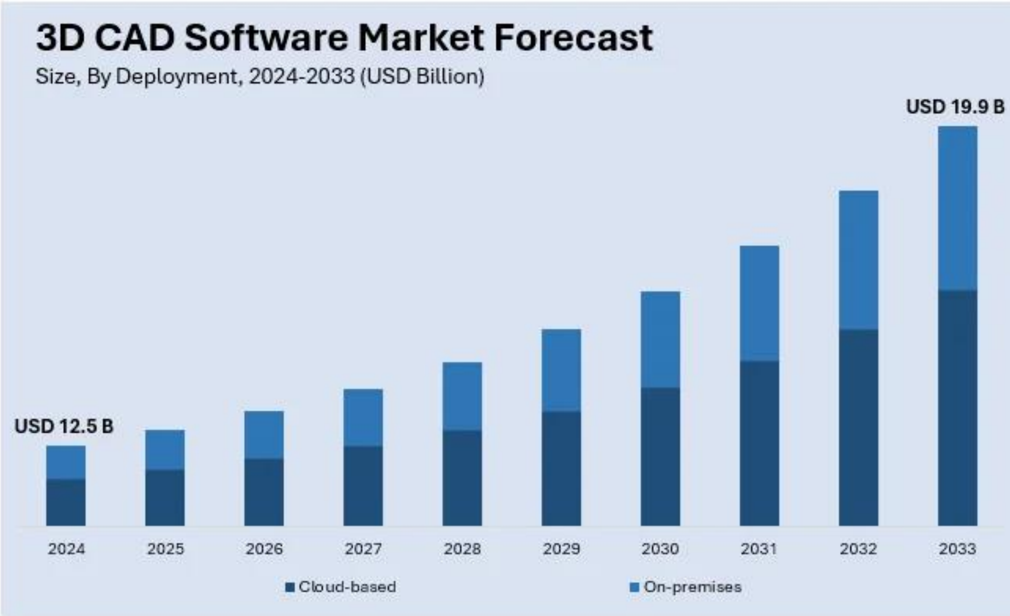

Fig.1. The growth rate of 3D CAD software [7]

CAD solutions are comprehensive platforms encompassing various aspects of design. These systems enable the creation of models, drawings, and analyses while integrating data with other enterprise systems. Modern technologies for modeling, calculations, and virtual testing significantly reduce development time and lower costs previously required for solving similar tasks.

CAD systems incorporate both traditional and parametric modeling, allowing for the design of not only static objects but also dynamic structures where elements are interconnected through parameters. Parametric modeling facilitates system modifications, simplifies the adjustment process, and minimizes the impact of errors.

Integrated tools for structural analysis, thermal simulations, and aerodynamic testing help identify defects during the design stage. These features allow for the simulation of operating conditions without creating physical prototypes, reducing errors in subsequent development stages.

CAD systems are integrated with production process management, product lifecycle management, and enterprise planning systems. This integration enables not only the design and testing of products but also the planning of their production and monitoring of their condition throughout their lifecycle.

CAD systems automate the generation of project documentation, including drawings, specifications, and reports. Standardizing these processes reduces the likelihood of errors and accelerates the preparation of materials for further development and production [1, 3, 5].

Thus, CAD systems play a critical role in automating design and prototyping. These platforms accelerate development, minimize errors at all stages of product creation, and contribute to higher product quality. As the complexity of engineering tasks continues to grow, the role of these technologies will expand, offering new opportunities for innovation and increased development efficiency.

DISCUSSION

Modern computer-aided design (CAD) systems are powerful tools that integrate the entire development process into a unified ecosystem. The structure, elements, and interconnections of these systems are illustrated in Figure 2.

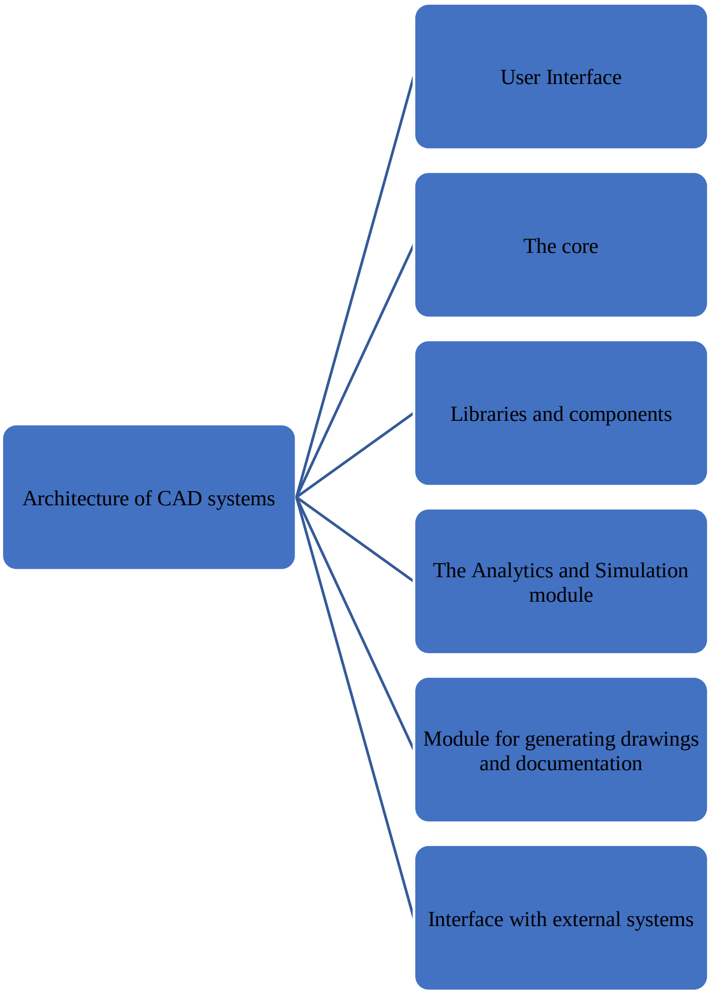

Fig.2. Architecture of CAD Systems (compiled by the author)

The architecture of CAD systems consists of a structure in which each element performs a predefined role:

- Interaction with the system is facilitated through graphical interfaces, voice commands, or virtual reality;
- The core executes basic functions, including object creation and modifications to dimensions or shapes;
- Libraries contain both standard and specialized components, which are applied depending on the specific industry (e.g., aerospace or mechanical engineering);
- The analytics module conducts model testing under various conditions, enabling calculations of strength, heat transfer, and electromagnetic properties;
- The interface with other systems enables the utilization of data from different production stages and the management of the product lifecycle. This is supported by information exchange standards such as STEP, IGES, XML, and APIs;
- The module for documentation generation supports both two-dimensional and three-dimensional drawings, including projection views and cross-sections [1, 2, 7].

During the modeling process, various mathematical methods are applied to create objects, enabling the automatic updating of interconnected model elements. Numerical methods are used to ensure analytical precision:

- Finite element analysis for calculating structural strength and stability;
- Thermal analysis for modeling temperature regimes, identifying areas prone to overheating;
- Aerodynamic analysis for calculating air resistance, using numerical methods to solve Navier-Stokes equations (approaches enabling equation solving through computational programs).

For the visualization of three-dimensional models, rendering methods (OpenGL or DirectX) are applied. In data exchange between platforms, CAD systems utilize the following standards:

- STEP (ISO 10303), a standard for exchanging 3D models;
- IGES, a format for transmitting both two-dimensional and three-dimensional graphical elements;
- DXF, used for sharing drawings or other project documentation;
- STL, a format for transferring 3D models intended for subsequent 3D printing.

With the advancement of cloud technologies, CAD systems now operate in distributed computing environments, enabling collaborative editing and model modifications. For complex computations, CAD systems utilize methods that process information with high precision.

Looking ahead, CAD systems continue to evolve by leveraging advancements in machine learning and neural networks, facilitating the automation of design processes and improving product quality through big data analysis. In the future, CAD systems are expected to incorporate tools for the automatic optimization of design solutions, enhancing efficiency across various industries [2, 3, 7].

Table 1 below outlines the future prospects for CAD system utilization.

Table 1. Prospects for the use of CAD systems [1, 4, 5, 7]

Factor	Description
Features of Development	CAD systems are integrated with CAM, CAE, and PLM, ensuring a complete development cycle. Transition to cloud platforms enables remote operation and facilitates data sharing among multiple teams. The implementation of virtual reality technologies allows prototype testing during the development stage.
Advantages	The automation of design and prototyping through CAD systems reduces the time required to create drawings and models. CAD systems minimize errors associated with manual design by providing automatic checks for compliance with standards and calculations. These systems reduce material and labor costs by enabling modeling and testing of structures before production, identifying potential issues at early stages.
Impact on Industries	In the automotive industry, CAD systems support the creation of complex, safe, and energy-efficient vehicles, accelerating the development and testing of prototypes. In aerospace engineering, CAD systems allow for the modeling and analysis of aerodynamic characteristics and virtual testing, which is crucial for creating aviation equipment. In the furniture and construction industries, CAD systems aid in developing detailed projects, optimizing material use, and improving quality.
Integration Features	The integration of CAD systems with CAM, CAE, and ERP (Enterprise Resource Planning) systems requires the use of standard data formats and protocols to ensure interoperability across production stages. Transitioning CAD systems to the cloud ensures access to data and projects from various devices, enhances work flexibility, and simplifies collaboration among geographically dispersed teams. Implementing CAD systems in large manufacturing companies necessitates the development of efficient solutions for storing, processing, and securing large volumes of data generated during the design process.

As examples of the use of CAD systems for automating design and prototyping processes, the experience of the following companies can be considered:

SHINING 3D, a leader in scanning technologies, released EXModel, software designed for 3D CAD applications. This software simplifies the transition from 3D scanning to CAD modeling, offering an intuitive interface and a seamless workflow.

Nextech AR Solutions Corp. launched Toggle3D, a SaaS platform based on artificial intelligence algorithms, designed for creating, designing, and subsequently scaling CAD 3D models.

PTC introduced Creo 11 and Creo+, the latest versions of its 3D modeling software, featuring advanced tools such as AI-based generative design, which improve product quality and optimize production processes.

CGTech entered into a partnership with 3DCAD, a Mexican engineering consultancy, to expand the application of its VERICUT simulation software in Mexico. This partnership will enhance VERICUT's capabilities, offering comprehensive "Industry 4.0" solutions to a wide range of organizations. The expertise of 3DCAD in design, machining, simulation, and project management, combined with CGTech's advanced manufacturing solutions, provides clients with a complete and efficient process.

Kubotek Kosmos and Mastercam announced a partnership to improve data integrity for aerospace component suppliers. Kubotek Kosmos software can now directly read part data from Mastercam files. Additionally, Zenex Computing became a new reseller of Kubotek Kosmos software products. This collaboration focuses on verifying CAD file translation to ensure accuracy in aerospace manufacturing. The partnership builds on ongoing collaboration between the two companies to deliver practical solutions to aerospace suppliers [7].

Thus, the technical architecture of CAD systems represents a comprehensive mechanism encompassing numerous components, from mathematical algorithms to interfaces for integration with external solutions. Integration with other systems and the use of cloud technologies make these systems flexible tools for development and production.

CONCLUSION

In conclusion, the key aspects of using CAD systems for design and prototyping have been identified. These technologies have proven to be effective in improving accuracy, accelerating development, and enhancing productivity. Modern computer-aided design systems offer the capability to create digital models used throughout all stages of the product lifecycle, from conceptual design to operation.

The analysis of various CAD systems demonstrated that their functionalities depend on the field of application. However, all systems provide integration capabilities with CAM and CAE platforms. This interaction optimizes development, minimizes errors, and improves product quality. The integration of CAD with other technologies encompasses not only design but also manufacturing, testing, and optimization, contributing to reduced development time and lower prototype production costs.

An important consideration is that the implementation of CAD systems depends on several factors, including the qualifications of specialists, the degree of integration with existing processes, and the availability of resources for staff training and technical support.

Thus, the use of CAD systems in design represents a step toward process automation, ultimately accelerating development and improving quality at all stages.

REFERENCES

Eltaief A. et al. Automated Assessment Tool for 3D Computer-Aided Design Models //Applied Sciences. – 2024. – Vol. 14 (11). – p. 4578.

Favi C. et al. A CAD-based design for manufacturing method for casted components //Procedia CIRP. – 2021. – Vol. 100. – pp. 235-240.

Crăcun R. S., Moroșanu G. A., Teodor V. G. Improving the quality of small pieces made by rapid prototyping //Annals of" Dunarea de Jos" University of Galati, Fascicle V, Technologies in machine building. – 2021. – Vol. 39. – pp. 19-24.

Manavis A. et al. Digital customization for product design and manufacturing: a case study within the furniture industry //Electronics. – 2024. – Vol. 13 (13). – p. 2483.

Buric M., Brcic M., Skec S. Towards Automated Drafting in CAD Systems //2021 4th International Conference on Electronics and Electrical Engineering Technology. – 2021. – pp. 233-238.

Peng F. Prototyping to Mass Production: Automated CAD Model and G-Code Optimization Framework for Industrial 3D Printing //2023 9th International Conference on Mechatronics and Robotics Engineering (ICMRE). – IEEE, 2023. – pp. 203-206.

3D CAD Software Market Size, Share, Trends and Forecast by Deployment, Application, and Region, 2025-2033. [Electronic resource] Access mode: https://www.imarcgroup.com/3d-cad-software-market (accessed 01.13.2025).