

OPTIMIZING PRODUCTION PROCESS BY INTEGRATING 3D MANUFACTURING TECHNOLOGY USING AUTODESK INVENTOR SOFTWARE TO IMPROVE EFFICIENCY

Muhammad Ali Chandra¹, Isminarti^{2*}, Fauziah³, Yahya Bin Mulyadi⁴, Mohamad Ilyas Abas⁵

¹Program Studi Perawatan dan Perbaikan Mesin, Politeknik Bosowa

^{2,3,4}Program Studi Teknik Mekatronika, Politeknik Bosowa

⁵Program Studi Ilmu Komputer Universitas Muhammadiyah Gorontalo

Corresponding: isminarti@politeknikbosowa.ac.id*

Submitted: 20-09-2024; Accepted: 08-11-2024; Published: 09-11-2024

ABSTRACT (10pt BOLD)

The concepts of efficiency and quality represent pivotal dimensions within contemporary manufacturing sectors. The amalgamation of manufacturing technology with design software, alongside the deployment of 3D scanning technology, is instrumental in the realization of these objectives, particularly within the framework of Industry 4.0. This investigation delves into the synthesis of manufacturing technology with design software and the utilization of 3D scanning technology in relation to Industry 4.0. More precisely, this research seeks to ascertain the most recent innovations in technology integration while assessing the advantages and obstacles associated with 3D scanning technology in the manufacturing domain. A methodological approach encompassing a literature review in conjunction with case studies is employed. Case studies were executed at PT. Metalindo Teknik Utama, a manufacturing entity, to examine the practical implications of technology integration. Qualitative analysis is used to identify patterns and critical findings. The study reveals significant advancements in technology integration, particularly in CAD, CAM, IoT, and IIoT, contributing to increased production efficiency and responsiveness to market changes. Additionally, Autodesk Inventor applications show potential in enhancing product design, evaluation, and production processes. These findings suggest that the integration of technology with design software and the adoption of 3D scanning technology have the potential to revolutionize the manufacturing process, improving efficiency and quality. This study emphasizes the importance of integrating manufacturing technology with design software and adopting 3D scanning technology in the manufacturing industry. Insights gained from this research provide valuable guidance for industry practitioners in optimizing production processes and remaining competitive in the era of Industry 4.0.

Keywords: Industry 4.0; Manufacturing Technology; Autodesk Inventor; Production Efficiency.

1. INTRODUCTION

Production efficiency and quality are two primary components heavily emphasised in modern manufacturing industries. Critical machines utilised in material forming and joining, such as shearing, bending, CNC, and MIG CO welding machines, are the foundation for various manufacturing processes. Understanding how to operate and optimize their performance is crucial for industry practitioners. These machines often feature increasingly complex interfaces due to technological advancements, demanding operators to possess strong technical knowledge. Conversely, the initial stage of the manufacturing process, product design, holds significant importance. Design software like AutoCAD, Inventor, and SolidWorks has become the industry standard for efficient and accurate product design. The context of Industry 4.0 and Education 4.0 is integral to the modern industrial transformation [1] [2] [3]. Industry practitioners and educators must also prepare learners to enhance their skills in facing advanced technologies within the increasingly digital manufacturing environment. It is essential to understand how to use software to accelerate the design process, reduce errors, and improve the quality of the final product.

A group of researchers discusses the application of digital technology in the manufacturing industry, including the use of Computer-Aided Design (CAD), Computer-Aided Manufacturing (CAM) software, and other digital techniques such as the Internet of Things (IoT) and Industrial Internet of Things (IIoT). Their findings indicate that the manufacturing industry is adopting advanced technologies to enhance efficiency and responsiveness to the ever-changing market demands [4]. Other researchers provide an overview of the latest developments in

manufacturing technology, focusing on the concept of Industry 4.0 and initiatives such as "Made-in-China 2025." They delve into current industry trends and how countries like Germany and China are adopting advanced technologies to enhance their industries. Additionally, they highlight the challenges faced in implementing the Industry 4.0 concept [5]. Another group of researchers also discusses using 3D scanning technology in the context of Industry 4.0. Their study explains how 3D scanning can be used in designing, assessing minor product features, scanning free-form objects, and providing accurate point clouds for complex geometries and curved surfaces. This illustrates how 3D scanning technology is among the emerging technologies in the industry and how it can play a crucial role in the culture of Industry 4.0 [6]. Another group of researchers also discusses the challenges and potential of implementing Industry 4.0 in the traditional manufacturing sector, particularly for small and medium-sized enterprises (SMEs) with limitations in investing in modern production technologies. These researchers highlight how Industry 4.0 can assist traditional sectors such as footwear, textiles and apparel, furniture, and toys in overcoming challenges like short product life cycles, highly customised products, and intense global competition. This underscores the importance of developing modular factory structures within computerised Internet of Things environments to support the Industry 4.0 revolution. The researchers also emphasise the complexity and high costs associated with manufacturing computerization, which hinder SMEs from adopting such technologies [7]. A study in Tanzania discusses the readiness of manufacturing industries to transition to the new paradigm of Quality 4.0 within the Industry 4.0 framework. Quality 4.0 integrates advanced technologies such as artificial intelligence, big data, and the Internet of Things (IoT) to enhance quality management practices. The study reveals that many industries in Tanzania still use Quality 3.0 methods, but there is high awareness of the Quality 4.0 concept and the potential benefits it offers, such as product improvement, customer satisfaction, and waste reduction. One of the key factors influencing this transition is organizational culture, which includes management support, skill training, and adequate technological infrastructure. In the context of Industry 4.0, industrial culture plays a crucial role in ensuring effective adoption of technology, as the success of the transition to Quality 4.0 depends not only on technology but also on the organization's readiness to change, both in terms of technology and culture [8].

From the perspective of integrating manufacturing technology with design software, despite advancements in the adoption of advanced technologies such as CAD, CAM, IoT, and IIoT in the manufacturing industry, there is still a need for a deeper understanding of how this technology integration, specifically can enhance production efficiency and responsiveness to market changes. Regarding the challenges and potential of Industry 4.0 in the traditional manufacturing sector, although Industry 4.0 offers significant opportunities for traditional manufacturing sectors, further research is needed on how this technology can be effectively implemented in SMEs with limited resources and technology investments. In the use of 3D scanning technology in Industry 4.0 while there is discussion on the use of 3D scanning technology in Industry 4.0, broader research is still needed on how this technology can be better integrated into the production process to achieve greater efficiency and product quality improvement. On the other hand, there is a need for more robust tools for Industry 4.0; despite discussions on challenges related to the complexity and high costs of manufacturing computerization, further research is needed on developing more robust and more affordable tools to support SMEs in adopting Industry 4.0 technology. Addressing these gaps in the future could significantly contribute to understanding and overcoming challenges in implementing advanced technology in the manufacturing industry and enhancing the capacity and competitiveness of traditional manufacturing sectors.

Based on the gap mentioned above analyses, this research focuses on the integration of manufacturing technology with design software, addressing two crucial aspects: identifying and analysing the latest advancements in technology implementation, such as CAD, CAM, IoT, and IIoT, in the manufacturing industry, and examining the use of 3D scanning technology in Industry 4.0. This involves evaluating the applications and benefits of 3D scanning technology in the context of Industry 4.0, analysing the weaknesses and challenges faced in integrating 3D scanning technology into the production process and developing methods and techniques to

enhance the integration of 3D scanning technology with the production process to improve efficiency and product quality.

2. METHOD

This research method involves a combination of literature review and case studies. This approach aims to comprehensively understand the integration of manufacturing technology with design software and evaluate the applications and benefits of 3D scanning technology in the context of Industry 4.0. The research process begins with data collection through a literature review, where data will be gathered by conducting a comprehensive review of the latest advancements in technology implementation, such as CAD, CAM, IoT, and IIoT, in the manufacturing industry [9] [10] [10]. The data sources include scholarly journals, conferences, books, and other official documents. The two case studies involve data collection from the manufacturing industry, specifically PT. Metalindo Teknik Utama specializes in manufacturing vehicle bodies, including chassis for buses or trucks. Data will be gathered through direct observation and interaction with industry personnel. The research analysis technique employed is qualitative analysis. Data from the literature review and case studies will be qualitatively analyzed to identify patterns, trends, and key findings related to integrating manufacturing technology with design software and utilizing 3D scanning technology in Industry 4.0. The data from the case studies will be analyzed to identify patterns and key findings related to practical experiences in integrating advanced technology into the production process. By employing this combination of research methods, data collection, and analysis techniques, the study aims to provide a comprehensive understanding of the integration of manufacturing technology with design software and 3D scanning technology in Industry 4.0. Additionally, it seeks to offer valuable insights for the manufacturing industry to enhance production efficiency and quality.

3. RESULT AND DISCUSSION

The first step in the production process is the fabrication of the subframe. This process involves shearing and bending machines to shape the main components of the subframe. Once the main components are formed, they are assembled into the subframe. This stage involves the use of other machines and the skills of operators to ensure that the elements are positioned correctly and securely assembled. After the subframe is constructed, the next step is the installation of the subframe into the final product. This installation process involves using additional tools and equipment, as well as operators' skills, to ensure that the subframe is installed correctly and according to specifications. Once the installation is complete, the final step in line 1 is to perform the first quality check (QC1) to ensure that the subframe and its installation meet the specified quality standards. This involves visual inspection and functional testing to detect and address quality issues. If the results of the QC1 inspection meet the quality standards, the process proceeds to the BAK assembly stage. However, if any quality issues are detected, the subframe will be returned to the production process for repair or remanufacturing.

After the BAK assembly process is completed, the steps in line 2 are as follows: the first step is to perform the second quality check (QC2). This inspection aims to ensure that all components have been correctly installed and that no quality issues have been overlooked during the assembly process. If the product passes the QC2 inspection, the process proceeds to the next step. However, if any quality issues are detected, the product will be returned to the BAK assembly process for repair. If the product passes the QC2 inspection, the next step is to mount the BAK onto the chassis or appropriate unit. This process involves the use of tools and the skills of operators to ensure that the BAK is appropriately installed and meets specifications. After the BAK is installed, the next step is the body setting process or installation of internal components. This involves installing essential components inside the body or frame of the product, such as the engine, electrical system, and other elements.

This process requires technical expertise and special tools to ensure all components are installed correctly and meet standards.

After the body setting/IC process is completed, the next step is to perform the second quality check (QC2). The purpose of this inspection is the same as the previous QC2, which is to ensure that all components have been installed correctly and that no quality issues have been overlooked. If the product passes the second QC2 inspection, the process proceeds to the next step. However, if any quality issues are detected, the product will be returned to the previous process for repair. If the product passes the QC2 inspection, the final step is the electrical process or installation of the electrical system. This involves the installation of cables, switches, control panels, and other electrical components necessary for proper product operation. This process requires technical expertise in the installation and testing of electrical systems. After the electrical process is completed, the final step is to perform the last round of the second quality check (QC2). The goal remains the same: to ensure that all electrical components have been installed correctly and that no quality issues have been overlooked. The production process is complete if the product passes the final QC2 inspection. However, if any quality issues are detected, the product will be returned to the previous process for repair.

The grinding process is a stage where the product surface is smoothed or polished to achieve the desired level of smoothness. This can be done using various grinding tools and techniques according to the product's requirements. After the grinding process, the product will undergo the third quality check (QC3) stage. The purpose of QC3 is to ensure that the grinding process has been carried out correctly and that no defects or imperfections are visible on the product surface after this process. If the product passes the QC3 inspection, the next step is the painting process. Painting is done to provide a protective layer on the product surface and to achieve the desired aesthetic appearance. This process involves using paint and painting techniques that comply with the product specifications. After the painting, the product will undergo the third quality check (QC3) stage again. The goal remains the same: to ensure that the painting process has been carried out correctly and that there are no defects or imperfections visible on the product surface after this process. If the product passes the second QC3 inspection, then the product is considered ready and complete. The final step is to label the product as "Unit Ready," which means the product has passed all production stages and quality inspections well and is ready to be shipped or used. After being labelled as "Unit Ready," the product can be removed from the production line. According to the production management instructions, the product will then be diverted to temporary storage or shipped directly to customers. Thus, the above steps depict a series of steps in the production line after the grinding process until the product is ready to be shipped or used, focusing on quality inspection, painting, and final product preparation. Each step requires special attention to ensure the final product meets the pre-established quality standards. Figure 1 shows the production layout and component racks prepared for production.

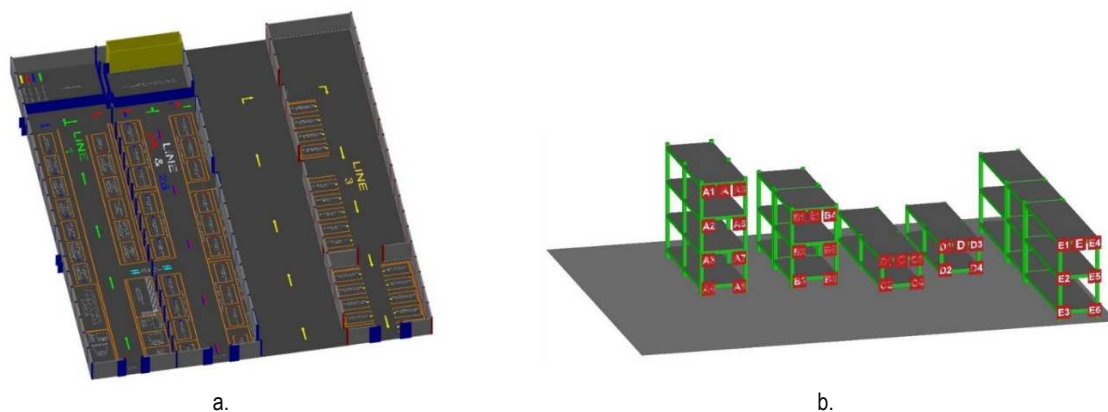


Figure 1. 3D Layout a. Production of PT. METALINDO TEKNIK UTAMA with 3 lines, b. Component Racks using AutoCAD Software.

Autodesk Inventor is a suite of software refinements from Autodesk AutoCAD and Autodesk Mechanical Desktop, which share a similar concept in 3D drawing. Autodesk Inventor is a parametric feature-based solid modeling program, meaning that all objects and relationships between geometry can be modified even after the geometry is completed without starting over from scratch. This dramatically facilitates designers in the product design process. To create a solid or surface 3D model, you must first sketch or import a 2D image from Autodesk Autocad. After completing the drawing or 3D model, you can create working drawings using drawing facilities. Autodesk Inventor not only stops at displaying working drawings but also provides simulation of product movements and has tools to analyze strength. These tools are easy to use and can help reduce errors in design. Thus, the costs that should be incurred for analysis are reduced, and the time to market for the designed object can be accelerated because the designed object is simulated on the computer before entering the production process. Figure 2 below shows a 3D image of a van monitor created using Autodesk Inventor.



Figure 2. 3D Van Monitor Interior and Exterior Parts using Autodesk Inventor Software

PT. Metalindo Teknik Utama is still using 3D image tools to facilitate product manufacturing to minimize product failures during field implementation but has not yet utilized IIoT to integrate all production devices, resulting in manual monitoring of results.

4. CONCLUSION

A case study was conducted at PT with a focus on integrating manufacturing technology with design software and using 3D scanning technology in the context of Industry 4.0. Metalindo Teknik Utama aimed to obtain practical data on technology integration in production. The study revealed that technologies such as CAD, CAM, IoT, and IIoT have improved production efficiency and responsiveness to market changes in the manufacturing industry. 3D scanning technology also has great potential to enhance product quality and production efficiency in Industry 4.0. In the production stages, using design software such as Autodesk Inventor has helped expedite the design process, reduce errors, and enhance the quality of the final products. Additionally, integrating technology in the production process, such as using automated machines and 3D scanning, has contributed to improving production efficiency and product quality. Further research is needed to identify the best ways to integrate advanced technology into the production process to achieve greater efficiency and product quality improvements.

STATEMENT

Thank you so much for the opportunity to conduct this research. The collaboration and support from the entire Production Department team have been invaluable to the smoothness and success of this study. Hopefully, the findings of this research will contribute to the development of the manufacturing industry, including our company, in the future..

REFERENCES

- [1] D. Mourtzis, "Development of skills and competences in manufacturing towards education 4.0: A teaching factory approach," *Lect. Notes Mech. Eng.*, vol. 0, no. 9783319895628, pp. 194–210, 2018, doi: 10.1007/978-3-319-89563-5_15.
- [2] G. Spöttl and L. Windelband, "The 4th Industrial Revolution—Its Impact on Vocational Skills," *J. Educ. Work*, vol. 34, no. 1, pp. 29–52, 2021, doi: 10.1080/13639080.2020.1858230.
- [3] F. F. de Souza, A. Corsi, R. N. Pagani, G. Balbinotti, and J. L. Kovaleski, "Total quality management 4.0: adapting quality management to Industry 4.0," *TQM J.*, vol. 34, no. 4, pp. 749–769, 2022, doi: 10.1108/TQM-10-2020-0238.
- [4] K. C. Rath, R. Kumar, and B. K. Mishra, "Implementation of the Industrial Internet of Things (IIoT) Is the Tool of Digital Transformation Technology," *Internet Things Technol. Adv. New Appl.*, pp. 61–84, 2023, doi: 10.1201/9781003304609-4.
- [5] L. Da Xu, E. L. Xu, and L. Li, "Industry 4.0: State of the art and future trends," *Int. J. Prod. Res.*, vol. 56, no. 8, pp. 2941–2962, 2018, doi: 10.1080/00207543.2018.1444806.
- [6] A. Haleem *et al.*, "Exploring the potential of 3D scanning in Industry 4.0: An overview," *Int. J. Cogn. Comput. Eng.*, vol. 3, pp. 161–171, 2022, doi: 10.1016/j.ijcce.2022.08.003.
- [7] A. Jimeno-Morenilla, P. Azariadis, R. Molina-Carmona, S. Kyratzi, and V. Moulitanitis, "Technology enablers for the implementation of Industry 4.0 to traditional manufacturing sectors: A review," *Comput. Ind.*, vol. 125, 2021, doi: 10.1016/j.compind.2020.103390.
- [8] D. P. Maganga and I. W. R. Taifa, "The readiness of manufacturing industries to transit to Quality 4.0," *Int. J. Qual. Reliab. Manag.*, vol. 40, no. 7, pp. 1729–1752, 2023, doi: 10.1108/IJQRM-05-2022-0148.
- [9] K. C. Rath, P. Chatterjee, P. M. Patro, P. Bojja, A. Kumar, and R. P. Das, "3D Printing technology in smart manufacturing systems for efficient production process," *Intell. Manuf. Manag. Syst. Oper. Appl. Evol. Digit. Technol. Mech. Ind. Eng.*, pp. 85–111, 2023, doi: 10.1002/9781119836780.ch4.
- [10] H. Zhang, A. Dzyatkovskii, U. Hryneuski, A. Krylova, and A. Dudov, "Secondary Development of CAD Software for the Construction of Mechanical Product Design System," *Comput. Aided. Des. Appl.*, vol. 20, pp. 178–189, 2023, doi: 10.14733/cadaps.2023.S3.178-189.