

## THE USAGE OF KAIZEN IN INDUSTRY 4.0 CONDITIONS

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**Purpose:** The purpose of this publication is to present the usage of Kaizen approach in Industry 4.0 conditions.

**Design/methodology/approach:** Critical literature analysis. Analysis of international literature from main databases and polish literature and legal acts connecting with researched topic.

**Findings:** The integration of Kaizen principles into the realm of Industry 4.0 signifies a strategic alignment between time-honored doctrines of continuous improvement and the revolutionary technologies characterizing the fourth industrial era. Originating from post-World War II Japanese reconstruction, Kaizen has evolved into a global philosophy guiding organizations toward sustained growth and excellence. In the context of Industry 4.0, marked by automation and artificial intelligence, Kaizen serves as a catalyst, seamlessly aligning with the dynamic nature of continuous improvement. Emphasizing data-driven decision-making and smart manufacturing, Kaizen becomes integral to organizations aspiring for efficiency and excellence in the digital landscape. Beyond methodologies, the integration fosters a cultural evolution, exemplified by virtual Kaizen events, employee empowerment, and digital tool optimization, contributing to a culture of continuous improvement. Tables 2 and 3 illustrate the holistic integration and advantages of Kaizen in Industry 4.0, while Table 4 acknowledges potential challenges and offers strategic solutions. Ultimately, this integration represents a transformative journey from historical recovery to a globally recognized philosophy, guiding organizations toward continuous improvement, adaptability, and excellence in the dynamic landscape of the fourth industrial revolution.

**Originality/Value:** Detailed analysis of all subjects related to the problems connected with the usage of kaizen in Industry 4.0 conditions.

**Keywords:** Industry 4.0; Quality 4.0, quality management; quality methods, QFD, Kaizen.

**Category of the paper:** literature review.

## 1. Introduction

The integration of Kaizen principles into the context of Industry 4.0 signifies a strategic alignment between a traditional philosophy of continuous improvement and the cutting-edge technologies characterizing the fourth industrial revolution. Industry 4.0, marked by the extensive use of automation, data exchange, the Internet of Things (IoT), and artificial intelligence, has redefined the landscape of manufacturing and production.

In the realm of Industry 4.0, Kaizen serves as a catalyst for maximizing the potential of advanced technologies. The emphasis on continuous improvement aligns seamlessly with the dynamic nature of Industry 4.0, where adaptability and responsiveness to change are paramount (Alrabadi et al., 2023).

The purpose of this publication is to present the usage of Kaizen approach in Industry 4.0 condition.

## 2. The basics of Kaizen approach

Kaizen, a Japanese term meaning "change for better" or "continuous improvement", has become a guiding philosophy for organizations worldwide seeking excellence and efficiency. Rooted in the principles of incremental progress and a commitment to constant refinement, Kaizen has evolved into a comprehensive methodology that extends far beyond its origins in manufacturing. This text explores the multifaceted nature of Kaizen, breaking down its key components into digestible bullet points to elucidate its significance in various aspects of life (Bousdekis et al., 2023).

The history of Kaizen, a term rooted in Japanese philosophy, can be traced back to the post-World War II era. In the aftermath of the devastating conflict, Japan faced the monumental task of rebuilding its economy. Influenced by American management practices introduced during the occupation, Japanese industrial leaders sought innovative approaches to enhance productivity and quality.

The concept of Kaizen began to take shape in the 1950s as a response to the pressing need for economic recovery. It gained momentum in the subsequent decades with the introduction of Quality Circles, small groups of workers who convened regularly to discuss ways to improve processes and address quality issues. Notably, the principles of Kaizen found a prominent application in the Toyota Production System (TPS), where continuous improvement became a cornerstone of manufacturing practices (Antony et al., 2023; Escobar et al., 2023; Antony et al., 2023; Salimbeni, Redchuk, 2023).

As Japanese companies like Toyota started to dominate global markets, interest in their management methodologies, including Kaizen, surged. The philosophy expanded beyond manufacturing and made inroads into various industries, such as healthcare, education, and services. In the 1990s, Kaizen became closely associated with the principles of lean manufacturing, emphasizing efficiency, waste reduction, and value creation. Organizations began to conduct "Kaizen events", focused, time-limited efforts to address specific problems and improve processes (Liu et al., 2023).

The 21st century witnessed the continued evolution of Kaizen, adapting to the digital age and incorporating technology into continuous improvement efforts. Beyond specific methodologies, Kaizen became synonymous with a mindset of continuous improvement woven into the fabric of an organization's culture.

Today, the history of Kaizen reflects its journey from post-war recovery efforts to a globally recognized management philosophy. Its enduring principles continue to guide organizations of all sizes, emphasizing the value of a culture that fosters constant learning, employee involvement, and adaptation in the pursuit of sustainable growth and excellence.

One significant aspect of the integration lies in leveraging data-driven decision-making. Kaizen, with its commitment to incremental progress based on data analysis, complements the vast amounts of data generated by interconnected devices in Industry 4.0. Organizations adopting Kaizen principles in this context harness the power of real-time information to identify areas for improvement, optimize processes, and enhance overall efficiency (Maganga, Taifa, 2023).

Furthermore, the application of Kaizen in Industry 4.0 extends to the concept of smart manufacturing. By incorporating the philosophy into smart factories, organizations can create an environment where continuous improvement is embedded in the very fabric of automated and interconnected systems. This extends beyond traditional manufacturing processes to include the optimization of supply chains, logistics, and product lifecycle management. The advent of Industry 4.0 has also seen the evolution of Kaizen events. In the current landscape, these events may involve not only physical spaces but also virtual environments where teams collaborate using digital tools and platforms. This allows for a more global and interconnected approach to problem-solving and improvement initiatives (Maganga, Taifa, 2023).

In essence, the usage of Kaizen in Industry 4.0 conditions represents a strategic evolution of a time-tested philosophy. By seamlessly integrating with advanced technologies, Kaizen becomes a driving force behind the continuous improvement efforts necessary for thriving in the rapidly evolving and interconnected industrial landscape of the fourth industrial revolution (Jonek-Kowalska, Wolniak, 2021; 2022).

Table 1 contains description of Kaizen key principles. These principles collectively form the foundation of Kaizen, promoting a culture of continuous improvement, employee engagement, and efficiency within an organization.

**Table 1.**  
*Key principles of Kaizen*

Key principle	Description
<b>Continuous Improvement</b>	Ongoing, incremental changes are prioritized over radical shifts, fostering steady progress.
<b>Employee Involvement</b>	All members of the organization, from top management to frontline workers, contribute ideas.
<b>Gemba (Real Place)</b>	Solutions are sought at the source of the issue, often on the shop floor or in the workspace.
<b>Standardization</b>	Once improvements are made, standardized processes are established to maintain consistency.
<b>Elimination of Waste</b>	Identification and removal of unnecessary processes, movements, and resources to optimize.
<b>Kaizen Events</b>	Time-limited, focused activities to address specific issues and rapidly implement improvements.
<b>Quality Focus</b>	A commitment to producing high-quality products or services is central to the Kaizen philosophy.
<b>Visual Management</b>	Information is presented visually to enhance understanding and facilitate quick decision-making.
<b>Cross-Functional Teams</b>	Collaboration among individuals from different departments to address issues comprehensively.
<b>Data-Driven Decision-Making</b>	Analysis of data guides decision-making, ensuring changes are based on evidence and facts.

Source: (Almeida, Abreu, 2023; Jokovic et al., 2023; Khourshed, Gouhar, 2023; Maganga, Taifa, 2023; Liu et al., 2023; Yanamandra et al., 2023; Escobar et al., 2023; Bousdekis et al., 2023; Antony et al., 2023).

### 3. How Kaizen method can be integrated with Industry 4.0 and Quality 4.0 concept

The integration of the Kaizen method with Industry 4.0 represents a strategic convergence of time-tested principles and cutting-edge technologies. Several crucial aspects define this integration, shaping the way organizations optimize processes, engage their workforce, and leverage advanced digital tools. In the realm of Industry 4.0, data-driven decision-making takes center stage. The Kaizen method seamlessly aligns with this paradigm, where the abundance of data from interconnected devices informs real-time decision-making. Incremental progress, a core tenet of Kaizen, aligns with the dynamic nature of Industry 4.0, emphasizing the continuous refinement of processes (Singh et al., 2023).

Smart manufacturing, an integral component of Industry 4.0, sees the application of Kaizen principles. Beyond the shop floor, organizations extend continuous improvement efforts to encompass the entire value chain, integrating supply chains, logistics, and product lifecycle management within a holistic framework. The integration fosters a culture of continuous improvement within the digital landscape. Kaizen serves as a guiding philosophy, encouraging adaptability and responsiveness to change. This aspect ensures that employees are not only participants in the digital transformation but active contributors to the ongoing improvement initiatives (Gajdzik et al., 2023).

Virtual Kaizen events mark a shift in problem-solving dynamics. These events, traditionally conducted in physical spaces, evolve to include virtual environments. Teams collaborate using digital tools and platforms, reflecting the need for flexibility in addressing challenges and implementing improvement initiatives in a digital context (Yanamandra et al., 2023). Employee empowerment is a cornerstone of the integration. As Industry 4.0 introduces advanced technologies, Kaizen principles emphasize that employees' insights and expertise are indispensable. The method ensures that the human element remains central in leveraging these technologies effectively to achieve excellence (Jokovic et al., 2023).

Optimizing digital tools becomes a continuous process. Kaizen principles are applied to refine the use of digital technologies within Industry 4.0 actively. The focus is on enhancing efficiency, minimizing waste, and extracting maximum value from digital tools as part of the broader pursuit of continuous improvement. Adaptability is crucial in Industry 4.0, and Kaizen's agile approach aligns perfectly with this requirement. Organizations embracing the integration respond quickly to changes in the technological landscape, adopting an open mindset for experimentation, learning from experiences, and continuously refining strategies and processes (Barsalou, 2023; Maganga, Taifa, 2023).

Table 2 is listing examples of integration of Kaizen method with industry 4.0. These aspects collectively illustrate how the integration of Kaizen with Industry 4.0 is a holistic approach that addresses various facets of modern manufacturing and production in the digital era.

**Table 2.**

*Kaizen integration with Industry 4.0*

<b>Aspect</b>	<b>Description</b>
<b>Data-Driven Decision-Making</b>	Utilizing the vast amounts of data generated by interconnected devices and systems to inform decision-making processes. Kaizen's commitment to incremental progress aligns with the dynamic nature of Industry 4.0 and its reliance on real-time data.
<b>Smart Manufacturing</b>	Applying Kaizen principles to optimize automated and interconnected manufacturing processes within smart factories. This extends to the entire value chain, incorporating supply chains, logistics, and product lifecycle management.
<b>Continuous Improvement Culture</b>	Embedding a culture of continuous improvement into the fabric of automated and digital systems. Kaizen serves as a guiding philosophy, encouraging adaptability and responsiveness to change in the rapidly evolving landscape of Industry 4.0.
<b>Virtual Kaizen Events</b>	Evolving traditional Kaizen events to include virtual environments, where teams collaborate using digital tools and platforms. This global and interconnected approach enhances problem-solving and improvement initiatives in the digital era.
<b>Employee Empowerment</b>	Empowering employees to actively contribute to improvement initiatives in the digital age. With Industry 4.0, workers may engage with advanced technologies, and Kaizen ensures that their insights and expertise are valued in the pursuit of excellence.
<b>Optimization of Digital Tools</b>	Applying Kaizen principles to optimize the use of digital tools and technologies within Industry 4.0. This involves ensuring that the technologies in place are continuously refined to enhance efficiency, minimize waste, and improve overall performance.

Cont. table 2.

<b>Agile and Adaptive Strategies</b>	Embracing Kaizen's agile approach to adaptability, allowing organizations to respond quickly to changes in the Industry 4.0 landscape. This includes being open to experimentation, learning from experiences, and continuously refining strategies and processes.
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Source: (Almeida, Abreu, 2023; Jokovic et al., 2023; Khoureshed, Gouhar, 2023; Maganga, Taifa, 2023; Liu et al., 2023; Amat-Lefort et al., 2023; Alrabadi et al., 2023; Singh et al., 2023; Barsalou, 2023; Antony et al., 2023; Saihi et al., 2023; Sureshchandar, 2023; Swarnakar et al., 2023; Gimerska et al., 2023; Salimbeni, Redchuk, 2023; Yanamandra et al., 2023; Escobar et al., 2023; Bousdekis et al., 2023; Antony et al., 2023).

Table 3 is describe the advantages Kaizen approach usage in industry 4.0. These advantages collectively illustrate how the Kaizen approach enhances the adaptability, efficiency, and overall performance of organizations in the context of Industry 4.0.

**Table 3.**

*The advantages of Kaizen integration with industry 4.0*

<b>Advantage</b>	<b>Description</b>
<b>Continuous Improvement</b>	Kaizen's commitment to incremental progress aligns with the dynamic nature of Industry 4.0, allowing for ongoing optimization of processes.
<b>Adaptability to Change</b>	The agile nature of Kaizen ensures that organizations can readily adapt to the rapidly evolving landscape of Industry 4.0, embracing technological advancements.
<b>Data-Driven Decision-Making</b>	Kaizen leverages the abundance of data in Industry 4.0, facilitating informed decision-making and strategic planning based on real-time insights.
<b>Enhanced Employee Engagement</b>	The Kaizen approach empowers employees to actively contribute to improvement initiatives, fostering a culture of engagement and innovation.
<b>Optimization of Digital Tools</b>	Kaizen principles actively contribute to refining the use of digital technologies, ensuring efficient and effective utilization within Industry 4.0 environments.
<b>Global Collaboration</b>	Virtual Kaizen events enable global collaboration, allowing teams to work seamlessly across borders and leverage diverse expertise for problem-solving.
<b>Human-Centric Approach in Automation</b>	Kaizen ensures that the human element remains central in the integration of advanced technologies, balancing automation with the expertise and insights of the workforce.
<b>Efficiency and Waste Reduction</b>	Industry 4.0, guided by Kaizen principles, focuses on minimizing waste and optimizing efficiency across the entire value chain, from production to logistics.
<b>Cultural Integration of Continuous Improvement</b>	The Kaizen approach seamlessly integrates with the organizational culture, promoting a mindset of continuous improvement that aligns with the principles of Industry 4.0.
<b>Agile and Adaptive Strategies</b>	Kaizen's agile approach supports Industry 4.0 by facilitating quick adjustments to strategies, ensuring organizations remain responsive to technological shifts and market demands.

Source: (Almeida, Abreu, 2023; Jokovic et al., 2023; Khoureshed, Gouhar, 2023; Maganga, Taifa, 2023; Liu et al., 2023; Amat-Lefort et al., 2023; Alrabadi et al., 2023; Singh et al., 2023; Barsalou, 2023; Antony et al., 2023; Saihi et al., 2023; Sureshchandar, 2023; Swarnakar et al., 2023; Gimerska et al., 2023; Salimbeni, Redchuk, 2023; Yanamandra et al., 2023; Escobar et al., 2023; Bousdekis et al., 2023; Antony et al., 2023).

Table 4 is describe the problems of Kaizen approach usage in Industry 4.0 and methods to overcome them. Addressing these problems requires a strategic and thoughtful approach, involving a combination of technological solutions, organizational change management, and ongoing adaptation to evolving industry standards and practices.

**Table 4.**  
*The problems of Kaizen integration with industry 4.0*

<b>Problems</b>	<b>Description of Problem</b>	<b>Overcoming Strategies</b>
<b>Resistance to Change</b>	Employees may resist adopting the Kaizen approach or Industry 4.0 technologies due to fear of job displacement, unfamiliarity, or a reluctance to alter established workflows.	Implement comprehensive change management programs that include communication, training, and involvement of employees in the decision-making process. Highlight the benefits of Kaizen and Industry 4.0, emphasizing skill enhancement and job enrichment.
<b>Lack of Digital Literacy</b>	The successful integration of Industry 4.0 technologies may be hindered by a lack of digital literacy among the workforce, limiting their ability to effectively use and maximize the potential of new tools.	Invest in training programs to enhance digital literacy. Provide ongoing education and support to ensure employees are comfortable and proficient with the technologies involved. Encourage a culture of continuous learning.
<b>Integration Challenges</b>	Integrating Kaizen principles with advanced digital technologies can be complex, especially if existing systems are not designed to seamlessly interact with Industry 4.0 solutions.	Conduct thorough assessments of existing systems, and invest in flexible and interoperable technologies. Implement phased integration plans, allowing for gradual adoption and addressing challenges in smaller, manageable steps.
<b>Data Security Concerns</b>	The increased reliance on data in Industry 4.0 raises concerns about data security and privacy. Organizations may face challenges in ensuring the integrity and confidentiality of sensitive information.	Implement robust cybersecurity measures, including encryption, access controls, and regular security audits. Develop and communicate clear data privacy policies. Involve employees in cybersecurity awareness programs to foster a collective commitment to data security.
<b>Overemphasis on Technology</b>	Organizations might focus too much on the implementation of new technologies without adequately addressing the cultural and human aspects essential for the success of Kaizen and Industry 4.0.	Maintain a balance between technological advancements and cultural integration. Prioritize a people-centric approach by emphasizing employee involvement, collaboration, and a culture of continuous improvement alongside technological upgrades.
<b>Lack of Standardization</b>	Inconsistencies in processes and practices can emerge if standardization is not adequately addressed, leading to challenges in maintaining quality and efficiency across different facets of the organization.	Establish clear standardization protocols and procedures. Regularly review and update standards to ensure relevance. Implement a robust communication system to disseminate standardized practices and encourage adherence across all levels of the organization.
<b>High Implementation Costs</b>	The integration of Industry 4.0 technologies can incur substantial upfront costs, including investments in hardware, software, and employee training. Managing these costs can be a significant challenge.	Develop comprehensive cost-benefit analyses before implementation. Explore phased implementation approaches to distribute costs over time. Seek partnerships and collaborations to share resources and expenses. Prioritize technologies that provide long-term value and align with organizational goals.
<b>Data Overload and Analysis Paralysis</b>	The abundance of data in Industry 4.0 can overwhelm organizations, leading to challenges in effectively analyzing and interpreting information. This can result in delayed decision-making and missed improvement opportunities.	Implement advanced analytics tools to streamline data analysis. Focus on actionable insights and prioritize key performance indicators. Invest in employee training to enhance data interpretation skills. Establish clear data governance policies to ensure data relevance and accuracy.

Source: (Almeida, Abreu, 2023; Jokovic et al., 2023; Khourshed, Gouhar, 2023; Maganga, Taifa, 2023; Liu et al., 2023; Amat-Lefort et al., 2023; Alrabadi et al., 2023; Singh et al., 2023; Barsalou, 2023; Antony et al., 2023; Saihi et al., 2023; Sureshchandar, 2023; Swarnakar et al., 2023; Gimerska et al., 2023; Salimbeni, Redchuk, 2023; Yanamandra et al., 2023; Escobar et al., 2023; Bousdekis et al., 2023; Antony et al., 2023).

## 4. Conclusion

The integration of Kaizen principles into the context of Industry 4.0 represents a powerful and strategic alignment between traditional philosophies of continuous improvement and the transformative technologies of the fourth industrial revolution. Industry 4.0, characterized by automation, data exchange, and artificial intelligence, has redefined manufacturing and production, making the incorporation of Kaizen principles a timely and valuable endeavor. The journey of Kaizen, rooted in post-World War II Japanese recovery efforts, has evolved into a global philosophy of continuous improvement. From its application in manufacturing, particularly in the Toyota Production System, to its expansion into diverse industries and its adaptation to the digital age, Kaizen has demonstrated enduring principles that guide organizations toward sustainable growth and excellence.

As Industry 4.0 unfolds, Kaizen serves as a catalyst for maximizing the potential of advanced technologies. The philosophy's emphasis on continuous improvement seamlessly aligns with the dynamic nature of Industry 4.0, where adaptability and responsiveness to change are paramount. Leveraging data-driven decision-making and embracing smart manufacturing, Kaizen becomes an integral part of organizations striving for efficiency and excellence in the digital landscape. The integration of Kaizen with Industry 4.0 goes beyond methodologies; it becomes a cultural evolution. Virtual Kaizen events, employee empowerment, and the optimization of digital tools exemplify the dynamic ways in which Kaizen principles adapt to the modern industrial environment. The approach fosters a culture of continuous improvement, ensuring that employees are not only participants in the digital transformation but active contributors to ongoing improvement initiatives.

Table 2 illustrates how Kaizen seamlessly integrates with Industry 4.0 across various aspects, such as data-driven decision-making, smart manufacturing, and continuous improvement culture. These aspects collectively showcase a holistic approach that addresses the multifaceted challenges of modern manufacturing and production. Furthermore, Table 3 outlines the advantages of employing the Kaizen approach in Industry 4.0 conditions. From continuous improvement to enhanced employee engagement, the benefits demonstrate how Kaizen contributes to the adaptability, efficiency, and overall performance of organizations within the rapidly evolving and interconnected industrial landscape.

Despite the evident advantages, Table 4 acknowledges potential challenges in implementing the Kaizen approach in Industry 4.0. Resistance to change, lack of digital literacy, integration challenges, and data security concerns are among the obstacles organizations may face. However, the provided strategies offer practical solutions, emphasizing the importance of comprehensive change management, ongoing education, and the thoughtful integration of technology and human elements.



The integration of Kaizen with Industry 4.0 represents a journey from historical recovery efforts to a globally recognized philosophy. It is a journey that continues to guide organizations towards continuous improvement, adaptability, and excellence in the dynamic and interconnected landscape of the fourth industrial revolution.

## References

1. Almeida, S., Abreu, L.P.M. (2024). The Quality Manager in the Industry 4.0 Era. *Lecture Notes in Mechanical Engineering*, 468-474.
2. Alrabadi, T.D.S., Talib, Z.M., Abdullah, N.A.B. (2023). The role of quality 4.0 in supporting digital transformation: Evidence from telecommunication industry. *International Journal of Data and Network Science*, 7(2), 717-728.
3. Amat-Lefort, N., Barravecchia, F., Mastrogiacomo, L. (2023). Quality 4.0: big data analytics to explore service quality attributes and their relation to user sentiment in Airbnb reviews. *International Journal of Quality and Reliability Management*, 40(4), 990-1008.
4. Antony, J., McDermott, O., Sony, M., Cudney, E.A., Doulatbadi, M. (2023). Benefits, challenges, critical success factors and motivations of Quality 4.0—A qualitative global study. *Total Quality Management and Business Excellence*, 34(7-8), 827-846.
5. Antony, J., Sony, M., McDermott, O., Jayaraman, R., Flynn, D. (2023). An exploration of organizational readiness factors for Quality 4.0: an intercontinental study and future research directions. *International Journal of Quality and Reliability Management*, 40(2), 582-606.
6. Antony, J., Swarnakar, V., Sony, M., McDermott, O., Jayaraman, R. (2023). How do organizational performances vary between early adopters and late adopters of Quality 4.0? An exploratory qualitative study. *TQM Journal*.
7. Barsalou, M. (2023). Root Cause Analysis in Quality 4.0: A Scoping Review of Current State and Perspectives. *TEM Journal*, 12(1), 73-79.
8. Bousdekis, A., Lepenioti, K., Apostolou, D., Mentzas, G. (2023). Data analytics in quality 4.0: literature review and future research directions. *International Journal of Computer Integrated Manufacturing*, 36(5), 678-701.
9. Escobar, C.A., Macias-Arregoyta, D., Morales-Menendez, R. (2023). The decay of Six Sigma and the rise of Quality 4.0 in manufacturing innovation. *Quality Engineering*.
10. Gajdzik, B., Jaciow, M., Wolniak, R., Wolny R., Grebski, W.W. (2023). Energy Behaviors of Prosumers in Example of Polish Households. *Energies*, 16(7), 3186; <https://doi.org/10.3390/en16073186>.
11. Gimerská, V., Šoltés, M., Mirdala, R. (2023). Improving Operational Efficiency through Quality 4.0 Tool: Blockchain Implementation and Subsequent Market Reaction. *Quality Innovation Prosperity*, 27(2), 16-32.

12. Jokovic, Z., Jankovic, G., Jankovic, S., Supurovic, A., Majstorović, V. (2023). Quality 4.0 in Digital Manufacturing – Example of Good Practice. *Quality Innovation Prosperity*, 27(2), 177-207.
13. Jonek-Kowalska, I., Wolniak, R. (2021). Economic opportunities for creating smart cities in Poland. Does wealth matter? *Cities*, 114, 1-6.
14. Jonek-Kowalska, I., Wolniak, R. (2022). Sharing economies' initiatives in municipal authorities' perspective: research evidence from Poland in the context of smart cities' development. *Sustainability*, 14(4), 1-23.
15. Khourshed, N., Gouhar, N. (2023). Developing a Systematic and Practical Road Map for Implementing Quality 4.0. *Quality Innovation Prosperity*, 27(2), 96-121.
16. Kordel, P., Wolniak, R. (2021). Technology entrepreneurship and the performance of enterprises in the conditions of Covid-19 pandemic: the fuzzy set analysis of waste to energy enterprises in Poland. *Energies*, 14(13), 1-22.
17. Liu, H.-C., Liu, R., Gu, X., Yang, M. (2023). From total quality management to Quality 4.0: A systematic literature review and future research agenda. *Frontiers of Engineering Management*, 10(2), 191-205.
18. Maganga, D.P., Taifa, I.W.R. (2023). Quality 4.0 conceptualisation: an emerging quality management concept for manufacturing industries. *TQM Journal*, 35(2), 389-413.
19. Olsen, C. (2023). Toward a Digital Sustainability Reporting Framework in Organizations in the Industry 5.0 Era: An Accounting Perspective. *Lecture Notes in Networks and Systems*, 557, 463-473.
20. Saihi, A., Awad, M., Ben-Daya, M. (2023). Quality 4.0: leveraging Industry 4.0 technologies to improve quality management practices – a systematic review. *International Journal of Quality and Reliability Management*, 40(2), 628-650.
21. Salimbeni, S., Redchuk, A. (2023). Quality 4.0 and Smart Product Development. *Lecture Notes in Networks and Systems*, 614. LNNS, 581-592.
22. Singh, J., Ahuja, I.S., Singh, H., Singh, A. (2023). Application of Quality 4.0 (Q4.0) and Industrial Internet of Things (IIoT) in Agricultural Manufacturing Industry. *AgriEngineering*, 5(1), 537-565.
23. Sureshchandar, G.S. (2023). Quality 4.0 – a measurement model using the confirmatory factor analysis (CFA) approach. *International Journal of Quality and Reliability Management*, 40(1), 280-303.
24. Wang, Y., Mo, D.Y., Ma, H.L. (2023). Perception of time in the online product customization process. *Industrial Management and Data Systems*, 123(2), pp. 369-385.
25. Yanamandra, R., Abidi, N., Srivastava, R., Kukunuru, S., Alzoubi, H.M. (2023). *Approaching Quality 4.0: The Digital Process Management as a Competitive Advantage*. 2nd International Conference on Business Analytics for Technology and Security, ICBATS 2023.