Application Of The Internet Of Things (IoT) In Production Management To Increase Production Efficiency In The Digital Era

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Article Info	ABSTRACT
Keywords: Internet of Things (IoT), Industrial Management, Production Efficiency, Digital Era	The digital era has brought significant changes to the production process, where the use of information technology and automation has become a key factor in increasing productivity and operational efficiency. This research aims to examine the application of the Internet of Things (IoT) in effective production management in increasing production efficiency in the digital era. This research uses a qualitative approach with descriptive methods. The research results show The use of the Internet of Things (IoT) in production management significantly increases efficiency by leveraging real-time monitoring, big data analysis, and connected system integration. IoT enables continuous monitoring of machine conditions through sensors, which helps detect problems early, perform predictive maintenance and optimize machine performance. Accurate and up-to-date data enables fast, data-driven decision making and rapid response to production disruptions. In addition, IoT makes it easier to document and analyze problems as well as systematic repairs, increasing maintenance effectiveness and production quality. However, IoT implementation also faces challenges such as data security, system integration, implementation costs, device interoperability, and dependency on network infrastructure. Managing these challenges well is important to harness the full benefits of IoT technology in improving production efficiency.
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INTRODUCTION

In the ever-growing digital era, effective production management is a key element for business success. Digitalization has brought significant changes in the way business operations are carried out, including in the production process (Syafi et al, 2023). Technologies such as the Internet of Things (IoT) have enabled companies to automate production processes, increase speed and accuracy, and reduce production costs. The use of this technology also allows companies to respond to market changes more quickly and flexibly, which is an important factor in maintaining competitiveness in this fast-paced era (Saputra, 2023).

In addition, the integration of digital technology in production management opens up opportunities for supply chain optimization. Digital technology allows better coordination between various parts of the supply chain, from procurement of raw materials to distribution of finished products (Apriani et al, 2023). With a digitally connected system,

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companies can identify and overcome obstacles in the production process more quickly, reduce downtime and increase overall efficiency. This not only increases productivity, but also helps companies to better meet customer demands, thereby increasing customer satisfaction and their loyalty (Suhairi et al, 2024).

Effective production management is the core of successful business operations, especially in the digital era that demands efficiency and timeliness. One important aspect of production management is coordination between various business functions such as production, marketing and finance (Rudiawan, 2021). This coordination ensures that every part of the organization works synergistically to achieve common goals. In a production context, this involves scheduling and proper allocation of resources, such as raw materials , labor, and machines, so that the production process can run smoothly without obstacles. By integrating marketing functions, companies can ensure that production is in line with market demand, avoiding overproduction or underproduction which can have a negative impact on profitability (Yuniarti, 2023).

Coordination between production and finance functions is also very important, especially in terms of cost management. Effective production management must consider cost aspects at each production stage to ensure that products can be produced efficiently without sacrificing quality (Sandopart et al, 2023). The finance function helps in providing the necessary budget, managing cash flow, and conducting cost-benefit analysis for every production decision. With good coordination between production and finance, companies can minimize production costs through strategies such as purchasing raw materials in bulk, using automation technology, and optimizing the use of labor (Julyanthry et al, 2020).

Apart from that, effective production management also requires proper resource scheduling. This scheduling not only includes the allocation of physical resources such as machines and raw materials , but also labor and production time. Good scheduling allows companies to maximize productivity, reduce downtime, and avoid delays in product completion (Nuraeni & Santoso, 2024). With the use of digital technology, companies can schedule more accurately and in real-time, allowing them to adapt quickly to changes in market demand or disruptions in the supply chain. For example, if there is a delay in the delivery of raw materials , the digital system can adjust the production schedule automatically to reduce the impact (Setiyawan et al, 2021).

Effective production management today requires a smarter and more integrated approach, especially with the rapid development of digital technology. One technological innovation that has proven its ability to increase production efficiency and quality is the Internet of Things (IoT) (Ulum. 2018). IoT offers advanced solutions by connecting various machines, equipment and production processes into one network system that can be accessed in real-time. Thus, IoT allows companies to collect, analyze and use data more effectively to monitor and optimize production operations (Shrouf & Miragliotta, 2015).

Utilizing IoT in production management provides various significant benefits. One of them is the ability to obtain real-time data from machines and equipment used in the production process (Alarcon et al, 2016). This data includes information about machine performance, operational status, and potential problems that may occur. With access to this

data, companies can identify problems early, even before serious disruptions occur, enabling predictive maintenance and reducing unexpected downtime. This not only increases operational efficiency but also reduces repair costs and production losses (Khan & Javaid, 2022).

In addition, IoT also enables deeper data analysis, which can be used to optimize the overall production process. Data collected from various stages of production can be analyzed to identify patterns, measure process effectiveness, and reveal areas requiring improvement (Yang et al., 2016). For example, companies can use data analysis to adjust production speeds, rearrange work schedules, or allocate resources more efficiently. With this in-depth analysis, companies can continue to improve their production processes, achieve higher efficiency and reduce waste (NI et al, 2023).

IoT integration in production management also has a significant impact on product quality. With real-time monitoring and proper analysis, companies can ensure that each product produced meets established quality standards (Ben-Daya et al, 2019. IoT-connected sensors can detect defects or anomalies during the production process, enabling immediate corrective action taken to prevent defective products from reaching consumers. In addition, data generated from the production process can be used to improve product design or manufacturing processes, thereby consistently improving product quality (Sallam et al., 2023).

The aim of this research is to analyze and identify effective strategies in implementing Internet of Things (IoT) technology in production management in order to improve operational efficiency and product quality in the digital era. It is hoped that this research will provide practical benefits for companies in understanding how IoT integration can optimize production processes, reduce costs, and increase competitiveness through improving quality and speed of response to market demand. Apart from that, it is also hoped that the results of this research can serve as a guide for decision makers in implementing appropriate digital technology to achieve long-term business success.

METHOD

This research uses an in-depth qualitative approach with literature analysis as the main method, as described by Alaslan (2022). This approach was chosen because of its ability to explore and understand complex phenomena more comprehensively. Through literature analysis, researchers can explore deeper meanings and relationships of various concepts, theories and findings that have been described in previous literature. This allows the researcher to gain a richer understanding of the research topic, which includes identifying theoretical patterns, synthesizing multiple arguments, and conceptually testing hypotheses. This approach is very effective in research that requires a thorough exploration of academic texts and arguments developed in the literature, thereby providing a strong theoretical basis for further analysis.

The data in this research was obtained from various library sources which include journal articles that are academically recognized, reference books that are considered authoritative in their field, and research reports that are relevant to the research topic (Niam

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et al., 2024). The use of these library sources provides a rich and varied framework for researchers to understand the phenomenon being researched from various points of view. The data source selection process was carried out with strict inclusion criteria, which ensured that only literature that had relevance and significant contribution to the research topic was selected. These inclusion criteria include factors such as the relevance of the content to the research objectives, the credibility of the sources, and the quality of the analysis offered in the literature. In this way , researchers can ensure that the data used is not only valid and reliable, but also provides deep and meaningful insight into the phenomenon under study.

RESULTS AND DISCUSSION

Application of the Internet of Things (IoT) in Production Management to Increase Production Efficiency

Internet of Things (IoT) is a revolutionary technology that allows various devices to connect and communicate wirelessly via the internet network. In the context of production management, IoT plays an important role by connecting production machines, production management software and sensors into one integrated ecosystem. This technology utilizes a network of connected sensors and devices to collect data in real-time from various points in the production process. With this collected information, companies can monitor machine performance and production processes in real time, identify potential problems before they develop into serious disruptions, and make faster, data-based decisions (Madakam et al., 2015).

One of the main applications of IoT in production management is real-time monitoring of machine and equipment conditions. Sensors installed on the machine can measure various parameters such as temperature, pressure, speed and vibration. This data is then sent to a connected production management system, enabling continuous monitoring of machine performance. With constant monitoring, companies can implement predictive maintenance, where corrective actions are taken before significant damage occurs. This not only reduces machine downtime but also extends equipment life, reduces maintenance costs and increases production efficiency (Saravanan et al, 2022).

Additionally, IoT also enables better integration between production management software and production control systems. With connected systems, information from multiple sources, such as machines, sensors, and software, can be collected and analyzed simultaneously. It provides a comprehensive picture of operational efficiency and allows companies to optimize production processes by adjusting operational parameters in real-time. For example, if data shows a decrease in performance on a machine, the system can automatically reset production parameters or shift the workload to another machine to maintain smooth production.

IoT technology also supports smarter decision making through big data analysis. Data collected from various sources can be analyzed to identify trends, patterns and anomalies in the production process. This analysis can be used to create predictive models that help companies plan production needs, manage raw material stocks , and forecast market

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demand. With more accurate and up-to-date information, companies can respond to market changes more quickly and effectively, reducing the risk of errors and increasing customer satisfaction.

The use of the Internet of Things (IoT) in production management provides important capabilities for monitoring production machine performance in real-time. IoT technology involves installing sensors on production machines that can measure various operational parameters such as temperature, pressure, speed and vibration. These sensors collect data continuously and transmit the information over a wireless network to a central management system. With this real-time monitoring, companies can gain direct insight into the operational conditions of machines, which is very important to ensure that the production process runs smoothly and without interruption (Tu et al., 2018).

One of the main advantages of real-time monitoring is the ability to detect problems or anomalies before they develop into serious damage. For example, sensors can identify abnormal temperature rises or vibrations, which may indicate mechanical problems or wear on engine components. With this early detection, companies can take necessary repair or maintenance actions before the problem causes significant downtime or damage to the machine. This not only reduces repair costs but also helps in maintaining the smoothness and continuity of the production process.

In addition to detecting problems, real-time monitoring also allows companies to optimize machine performance and production processes. Data collected from sensors can be analyzed to identify patterns or trends that impact operational efficiency. For example, data analysis may show that certain machines operate more efficiently at certain speeds or under certain environmental conditions. With this information, companies can adjust machine parameters and production processes to achieve optimal performance, increase productivity, and reduce waste of resources.

Furthermore, real-time monitoring supported by IoT technology also provides benefits in terms of planning and decision making. The information collected allows companies to make more data-based decisions regarding maintenance, repair and component replacement schedules. Additionally, real-time data can help in capacity planning and workload management, ensuring that machines operate at optimal capacity and avoid overloading or underloading. With effective data integration and analysis, companies can improve overall operational efficiency and reduce the risk of unexpected production disruptions (Zhong et al., 2017).

Furthermore, the use of the Internet of Things (IoT) in production management allows companies to make fast data-based decisions, an important advantage in a dynamic production environment. With an IoT system, companies can collect data from various sources in real-time, including machines, sensors and other devices connected to the network. This data includes information about machine performance, operational conditions and production status, all of which can be accessed and analyzed immediately. The ability to monitor and analyze data in real time provides more accurate and up-to-date insights, which is critical for fast and informed decision making.

One of the main benefits of data-driven decision making is the ability to respond immediately to changes or problems. For example, if real-time data shows that a machine is experiencing a decrease in performance or there is a disruption in the production process, managers can immediately make the necessary interventions. With accurate and up-to-date information, they can choose appropriate corrective actions, such as adjusting production parameters, performing maintenance, or shifting workloads to other machines. This not only reduces downtime but also minimizes negative impacts on production output and product quality.

In addition to responding to operational issues, data-driven decisions also enable companies to optimize overall production processes. By analyzing the data collected, companies can identify patterns or trends that affect efficiency and productivity. For example, data can reveal specific times of day where machines operate at optimal capacity or identify factors that cause bottlenecks in the production process. With this information, companies can make strategic decisions to manage production schedules, allocate resources efficiently, and plan necessary repairs or upgrades to improve overall system performance.

Finally, data-driven decision making supported by IoT also contributes to better planning and projections. Historical data and analytics generated from IoT systems can be used to predict production needs, manage raw material stocks , and adjust production strategies based on changing market demands. With the ability to make more accurate, data-driven projections, companies can reduce the risk of overstocking or understocking, ensuring that they can better meet customer demand and maintain a competitive advantage in the marketplace.

Finally, the use of the Internet of Things (IoT) in production management allows companies to identify and fix production problems more quickly and accurately, thanks to this technology's ability to provide real-time data from various sources in the production environment. Sensors installed on machines and equipment continuously collect information about various operational parameters, such as temperature, pressure, speed, and vibration. This data is sent directly to the production management system, allowing continuous monitoring of the condition of machines and production processes. With constant monitoring, companies can immediately detect any anomalies or deviations from normal parameters that could indicate a problem.

One of the main advantages of IoT-based monitoring is its ability to provide early warning of potential problems. For example, if the sensor detects an abnormally high temperature or abnormal vibration in the machine, the system will send a notification or alarm to the operator or maintenance team. With this early warning, companies can carry out inspections or corrective actions immediately before the problem develops into serious damage or causes significant production disruptions. This not only reduces machine downtime but also prevents losses associated with downtime and emergency repairs.

Apart from early detection, IoT also increases accuracy in the problem repair process. Data collected from sensors can provide deep insight into the root causes of production problems. For example, analysis of data from multiple connected sensors can help identify

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patterns or relationships between various parameters that influence machine performance. With this information, the maintenance team can determine the appropriate action to correct the problem, such as replacing specific components, adjusting operational parameters, or performing more specific repairs. Accuracy in problem identification and appropriate solutions increases the effectiveness of the maintenance process and reduces the risk of errors that can exacerbate the problem.

Furthermore, the use of IoT in production management enables systematic documentation and tracking of problems and repairs. Historical data collected from sensors can be used to analyze problem trends and improvements that have been made. By having a complete track record, companies can evaluate the effectiveness of maintenance actions, identify areas requiring further improvement, and develop more proactive maintenance strategies. This not only improves the company's ability to handle problems efficiently but also supports efforts to continuously improve the quality and reliability of production processes.

Challenges of Implementing the Internet of Things (IoT) in Production Management

The application of the Internet of Things (IoT) in production management offers many advantages, but also faces various challenges. Here are some of the main challenges you may face:

1. Data Security and Privacy :

Data security and privacy are the main challenges in implementing the Internet of Things (IoT) in production management due to the volume of data generated and the transmission of information over extensive networks. With so many connected IoT devices, there is a significant risk of potential cyberattacks and unauthorized access. Sensitive data collected from production machines, control systems and sensors can be a target for hackers looking to steal information or damage systems. Therefore, companies must implement comprehensive security measures, such as data encryption, multifactor authentication, and intrusion detection systems to protect information from external threats. Data security must be prioritized to maintain the integrity and confidentiality of critical information.

Additionally, privacy protection in the IoT context involves compliance with relevant regulations and ensuring that the data collected and processed is not misused. Companies need to implement clear and transparent privacy policies regarding how data is collected, used and shared. This also includes managing access permissions for data and protecting personal data from possible misuse. Managing compliance with privacy regulations, such as GDPR (General Data Protection Regulation) in Europe or local data privacy laws, as well as ensuring best practices in data management, are important steps to build customer trust and prevent the negative impact of potential privacy breaches.

2. System Integration

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3. Implementation Costs

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4. Operational Complexity

Operational complexity increases with the implementation of IoT in production management because the introduction of new technology requires significant adjustments in operational processes and procedures. Integrating IoT devices into existing production systems can add complexity to process management, requiring changes in work procedures, as well as additional training for staff. New technologies often require specialized technical expertise for operation and maintenance, which can increase workloads and require time and resources for training. Therefore, companies must carefully

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plan the integration process and provide adequate training to ensure that staff can manage the technology effectively and minimize operational disruption during the transition.

Additionally, changes in production processes and the introduction of new technology may require revisions in standard operating procedures (SOPs) and change management. Companies need to establish an effective change management strategy to address these challenges, including clear communication with all stakeholders and ongoing monitoring of the impact of new technologies. Managing operational complexity well involves regular assessments of IoT system performance, as well as feedback from staff regarding challenges encountered and necessary improvements. With a planned and proactive approach, companies can ensure that IoT technology is integrated successfully without disrupting the smooth running of production operations ..

5. Device Interoperability

Device interoperability is an important challenge in implementing IoT in production management because various devices and systems may be incompatible with each other . IoT devices from different vendors may use different standards or protocols, making integration and communication between devices difficult. These incompatibilities can hinder the system's ability to share data effectively and make it difficult to monitor and control the entire production process. To overcome these challenges, companies need to choose tools and systems that support open standards or use integration platforms specifically designed to address interoperability issues.

Additionally, meeting interoperability challenges requires a strategic approach to vendor and technology selection. Companies must ensure that the IoT solution chosen not only meets technical requirements but is also compatible with existing systems and other devices. Engaging technology providers that have a track record in developing interoperable solutions and working with vendors that support multi-platform integration can help mitigate these issues. With a thoughtful approach to selecting devices and systems, and adopting efficient integration solutions, companies can maximize the benefits of IoT technology and ensure that all devices can work harmoniously within their production ecosystem.

6. Dependency on Infrastructure

Dependence on network infrastructure is a significant challenge in implementing IoT in production management because the success of this technology is highly dependent on the quality and reliability of the network used. IoT involves many devices connecting and exchanging data in real-time, so it requires stable and high-quality network connectivity. If the network experiences interference or has low transfer speeds, IoT system performance can suffer, which can cause problems such as delayed data, communication errors between devices, and failures in monitoring or controlling production systems. Therefore, investing in reliable network infrastructure, including hardware such as high-quality routers and switches, as well as fast and stable internet connections, is critical to supporting effective IoT operations.

In addition, ongoing network monitoring and maintenance is also needed to ensure that the infrastructure can still meet the needs of the IoT system. This involves regular

monitoring of network performance, rapid troubleshooting if disruptions occur, and increasing network capacity if necessary to accommodate growing data volumes. Companies should also consider network redundancy and backup solutions to reduce the risk of disruption and ensure operational continuity. With a proactive approach to network infrastructure management and maintenance, companies can ensure that IoT systems function optimally and support successful, efficient production management.

CONCLUSION

The use of the Internet of Things (IoT) in production management significantly increases production efficiency by leveraging real-time monitoring, big data analysis, and connected system integration. IoT enables continuous monitoring of machine conditions through sensors that measure operational parameters such as temperature and vibration, so companies can detect problems early, perform predictive maintenance and optimize machine performance. With accurate and up-to-date data, companies can make faster, data-based decisions, respond immediately to production changes or disruptions, and optimize production processes and planning. In addition, IoT also facilitates systematic documentation and analysis of problems and repairs, increasing maintenance effectiveness and overall production process quality. The application of the Internet of Things (IoT) in production management faces various challenges, including data security and privacy, system integration, implementation costs, operational complexity, device interoperability, and dependence on network infrastructure. Data security and privacy require stringent protection measures, while system integration requires significant adjustments in processes and staff training. Implementation costs can be high, and interoperability between devices must be addressed by choosing solutions that support open standards. Dependence on network infrastructure demands stable connectivity and ongoing maintenance. Managing these challenges well is key to harnessing the full benefits of IoT technology in increasing production efficiency.

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