ISSN No:-2456-2165

Implementation of Artificial Intelligence in Integrated Manufacturing System

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Abstract:- Artificial Intelligence (AI) has become an integral part of industrial technology development, especially in the manufacturing sector. This research discusses the implementation of artificial intelligence in an integrated manufacturing system to improve production efficiency, productivity, and quality.An integrated manufacturing system is an approach that combines various aspects of production in one coordinated system, including planning, inventory management, production monitoring, and equipment maintenance. The implementation of artificial intelligence in these systems enables smarter decision-making, more accurate predictions, and more efficient automation.The methods used involve the use of machine learning and data analysis techniques to process and analyse production data in real time. In addition, the system also uses artificial intelligence algorithms to predict production disruptions, optimise production scheduling, and monitor equipment conditions continuously.The results show a significant improvement in production efficiency, a reduction in losses due to production interruptions, and an improvement in product quality. By integrating artificial intelligence in manufacturing systems, companies can respond more quickly to market changes, reduce production costs, and improve competitiveness.

This research provides insights into the importance of artificial intelligence implementation in the context of an integrated manufacturing industry. It also emphasises that investing in artificial intelligence technology is a crucial step for companies that want to stay relevant in the ever-changing industry 4.0 era..

Keywords:- *Artificial Intelligence, Process, Implementation, Manufacturing.*

I. INTRODUCTION

Artificial Intelligence (AI) is a field that increasingly dominates technological developments in various sectors, including in the manufacturing industry. The implementation of artificial intelligence in integrated manufacturing systems is an important step in responding to the demands for efficiency, productivity, and adaptability in an increasingly complex and rapidly changing industrial environment. This introduction will discuss the importance and scope of artificial intelligence implementation in integrated manufacturing systems (Lu, 2019; Lee &Yoon, 2021; Dhanabalan & Sathish, 2018; Javaid et al, 2022; Zhang & Lu, 2021).

Technological developments in recent years have opened the door to major advances in AI applications. AI has become key in solving complex problems that are difficult for humans to solve in a time-efficient manner. In the manufacturing industry, efficiency, quality, and adaptability are key factors that can differentiate successful companies from those that are not. The implementation of artificial intelligence is the solution to achieve these goals (M. Bublitz et al, 2019; Xu et al, 2021; Park et al, 2020; Benbya, Davenport &Pachidi, 2020; Abioye et al, 2021)

An integrated manufacturing system is a concept in which all aspects of production, from planning to delivery, are connected and operate together with mutually integrated information. This includes machine tools, production management, supply chain, maintenance, and performance monitoring. The system is designed to optimise production processes and make better decisions.

II. THE ROLE OF ARTIFICIAL INTELLIGENCE IN INTEGRATED MANUFACTURING SYSTEMS

Artificial intelligence can be applied in various aspects of integrated manufacturing systems:AI can be used to analyse historical data and predict demand, production, and inventory planning. Intelligent machines can automatically adjust production settings and parameters to improve efficiency and product quality. AI can monitor equipment performance and predict failures so that maintenance can be performed before breakdowns occur(Mukhamediev et al, 2022; Agarwal et al, 2022; Howard, 2019; Goralski, & Tan, 2020).

AI can help manage the supply chain more efficiently, including raw material procurement, inventory management, and product delivery.The benefits of AI Implementation in an Integrated Manufacturing System are that AI can improve production efficiency by reducing downtime and waste. Better process control and real-time quality monitoring can lead to better quality products. AI-integrated systems can quickly adapt to changes in demand or production conditions. Process optimisation and more efficient maintenance can reduce production costs.

While the implementation of artificial intelligence offers many benefits, there are some challenges that need to be overcome, including data privacy, cybersecurity, and integration with existing systems.With so many potential benefits, the implementation of artificial intelligence in integrated manufacturing systems is an important step to deal with the changing industrial environment that is constantly evolving. Successfully integrating AI in the manufacturing industry will provide a competitive

ISSN No:-2456-2165

advantage and help companies achieve better, efficient, and adaptive production goals.

III. LITERATURE REVIEW

A. *Definition of Artiffial Intelligence*

Artificial Intelligence (AI) is a field of computer science that deals with the development of computer systems capable of performing tasks that require human intelligence. Artificial intelligence aims to create programmes, machines, or systems that have the ability to think, learn, and make decisions similar to the way humans do (Yigitcanlar et al, 2020; Marr, 2019).

Artificial intelligence systems can be used for a variety of tasks, such as facial recognition, natural language processing, decision-making, pattern recognition, planning, and more. There are several approaches to the development of artificial intelligence, including machine learning, artificial neural networks, fuzzy logic, and more (Kumar, Lim,Sivarajah & Kaur, 2023).

The main goal of artificial intelligence is to create systems that can take data, analyse it, and use the information to make reasonable decisions or perform specific tasks without human intervention. Artificial intelligence has been used in various applications, such as autonomous vehicles, speech recognition, medical treatment, and more (Ghimire, Thapa, Jha, Adhikari & Kumar, 2020).

B. *Differences between Artificial Intelligence and Natural Intelligence*

Artificial Intelligence (AI) and Natural Intelligence (NI) are two different types of intelligence. Here are the main differences between the two:

➢ *Source of Intelligence:*

- Artificial Intelligence: This intelligence is created by humans through software development and machines. AI is the result of computer programming and data processing to execute a specific task.
- Natural Intelligence: Refers to the intelligence possessed by living beings, especially humans and some animal species. Natural intelligence develops naturally through the process of evolution.

➢ *Learning Ability:*

- Artificial Intelligence: AI has the ability to learn from data and experience. It can update their models and algorithms to improve their performance in a particular task.
- Natural Intelligence: IA has much more complex learning capabilities. Humans and some animals can learn from various experiences and adjust their behaviour according to evolving situations.

➢ *Objective:*

- Artificial Intelligence: AI is created with a specific purpose, such as performing computational, data processing, decision-making, or other tasks without human involvement.
- Natural Intelligence: IA is an integral part of human daily life. The main purpose of natural intelligence is to live, learn, communicate, and survive.

➢ *Usage:*

- Artificial Intelligence: AI is used in a variety of fields, including industrial automation, natural language processing, facial recognition, autonomous cars, and more.
- Natural Intelligence: IA is used by humans in various activities, such as thinking, speaking, creating art, pursuing science, and living everyday life.

➢ *Consciousness:*

- **Artificial Intelligence:** AI does not have human-like consciousness or understanding. They only perform tasks based on algorithms and data given to them.
- **Natural Intelligence:** Humans and some animal species have consciousness, understanding, feelings, and the ability to feel and think consciously.

While AI is constantly evolving and getting more sophisticated, it is still far from matching human natural intelligence in terms of complexity and depth of understanding. Artificial intelligence is more focused on specialised tasks, while natural intelligence incorporates various aspects such as emotions, creativity, and deep understanding.

C. *Meanwhile, the advantages of Natural Intelligence are:*

- Creative: humans have the ability to add knowledge, while in artificial intelligence to add knowledge must be done through a built system.
- Allows people to use experience directly. Meanwhile, artificial intelligence must work with symbolic inputs.
- Human thinking can be used extensively, whereas artificial intelligence is very limited.

D. *Industry and Government Challenges*

➢ *Industry Sector*

In the era of industry 4.0, many companies are figuring out how to adopt an Artificial Intelligence platform to be applied in their business processes. The strategy of integrating Artificial Intelligence, all starts from data acquisition, system structure design, to finding algorithms or methods that help solve complex problems in the production process from start to finish in the industry, especially the manufacturing industry (Sarker, 2022).

In reality, this technology is still too complex and requires considerable research and effort. Coupled with the algorithm mechanism that is fundamentally not only focused on engineering aspects, but also requires science aspects. Furthermore, the use of IT to transform traditional companies into companies that adopt technological trends in the industrial era 4.0 requires more than just building websites, information systems, or mobile applications (Soni, Sharma, Singh & Kapoor, 2020).

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By using AI or machine learning, some problems that cannot be solved only from the engineering side will be solved. Predictive modeling, for example, is now widely used by large e-commerce companies such as amazon, alibaba, and other giant companies.

- *Government Sector*

Industry 4.0 can help the government improve the economy which is more open, flexible, knowledge and skills-based, can promote local markets in the scope of international trade, increase efficiency and effectiveness in health and social care systems and many other potential benefits.There is a flip side to Industry 4.0 where governments are increasingly powerless in the face of megacorporations. People, whether individuals, corporations, or communities of interest, will use these technological trends to seek greater autonomy (Rouhiainen, 2018).

For example, blockchain technology could drive new approaches to banking and personal finance. Allowing individuals to choose to trade with one another in unofficial currencies like bitcoin rather than currencies run by central banks. So if governments are too slow to adopt new technologies in the industrial era 4.0, they will fail to improve the services needed to maintain the stability of public services, and lower the government's reputation.

In this case, it means that policymakers must be adaptive to the new environment that is rapidly changing, conduct internal evaluations so that they can fully understand what must be managed, and require sufficient Chief Information Officer (CIO) personnel to be able to play a full role in this matter.

E. Implementation of Artificial Intelligence

Artificial Intelligence is a technology that has been widely adopted in this industrial 4.0 era. Artificial Intelligence is able to connect every device, so that one can automate all devices without having to be on site. More than that, currently there are many machines that can interpret a certain condition or event with the help of Artificial Intelligence (Cioffi, Travaglioni, Piscitelli, Petrillo & De Felice, 2020).

One of them is a smart camera that detects vehicle volume density on the highway using Deep Learning Neural Network technology, which has been implemented in several district and city governments in supporting the Smart City program.

In the industrial sector, many have also automated production and manufacturing machines using robots and Artificial Intelligence, so Industry 4.0 increases competitiveness through smart devices. Any entity that is able to master this technology, then it has a competitive advantage.

However, in the midst of the massive development of Industry 4.0, the government must move quickly in adopting this platform, otherwise, they will reduce the efficiency of business processes to maintain the stability of public services.

Therefore, the correct knowledge and understanding is needed for the government to face the Industry 4.0 era, where the Chief Information Officer (CIO) can play an important role in providing support based on their knowledge of industry 4.0 technology trends, especially Artificial Intelligence which has been widely adopted in various sectors.

IV. MANUFACTURING

A. Manufacturing process

Manufacturing is defined as a set of interconnected activities and operations that include design, material selection, planning, production, quality assurance, management and marketing.Manufacturing is one of the essential elements of sustainable development as it produces the goods necessary to meet the needs of society. Manufacturing is an input-output system, where resources are inputs and transformed through manufacturing processes into products or semi-finished products (Sangwan and Mittal, 2015).

In most companies, including industrial manufacturing companies, long-term goals are generally emphasized on achieving a situation that the company continues to grow and develop and is able to generate reasonable profits.

B. Computer Integrated Manufacturing

Computer-integrated manufacturing (CIM) is a term used to describe the complete automation, planning of manufacturing processes, with all processes functioning under the control of computers and digital information carried out in a system together.

A business system integrated by a common data base). Computer-integrated manufacturing (CIM) is manufacturing that uses a computerized approach to control and integrate the entire production process. This integration allows individual processes or departments to exchange information with each other and take action. Through computer-integrated manufacturing (CIM), the manufacturing system carried out by a company can become faster by minimizing errors. Although the main goal is to improve the ability to automate manufacturing processes, CIM usually relies on control processes based on conditions or real-time information received through sensors. So, CIM is also known as flexible design for manufacturing.

At the heart of CIM are Computer Aided Design (CAD) and Computer Aided Manufacture (CAM). The CAD/CAM also has many benefits in the manufacturing system. The system in CAD/CAM is very important to reduce cycle time in an organization. CAD allows designers to create electronic drawings that can be made into two dimensions or three dimensions and can be rotated to view the entire perspective. This software program also provides facilities that can analyze and experiment with the design before realization. Moreover, CAM software also provides the facility to display the machining process flow that will be carried out on the product that has been designed. Another important use of CAD/CAM is as a database record. With a clear database of the products produced, the next time there is a small problem with the production

process, it can be identified as soon as possible.

A company that uses or applies CIM has many benefits. CIM is a complete form of automation in manufacturing facilities in a company. All functions in the manufacturing system are under computer control. The control function is carried out starting from the design process, prototyping, controlling and determining greater efficiency (calculating costs, production methods, quantities produced, storage and distribution), material requirements, machining starting from CAM, quality control, product assembly with robots, product distribution, and updating financial accounting.

CIM is a management philosophy, where all functions contained in the planning process to the manufacturing process are rationalized in an integrated manner with the application of computer, communication and information technology. (R. Widodo).

From the above definition, it can be seen that the element members of CIM are planning processes and manufacturing processes that complement each other.

Fig. 1: Computer Integrated Manufacturing System

Computer Integrated Manufacturing is a concept that combines computer technology and automation with production processes in the manufacturing industry. It aims to improve efficiency, accuracy, and flexibility in the production process. Below, we will discuss some key aspects about Computer Integrated Manufacturing:

- **Production Automation:** Computer Integrated Manufacturing involves the use of robust automation in various stages of production. This includes the use of robots, automatic control systems, conveyors, and other automated equipment to manage and move raw materials and products throughout the production chain. This automation can increase production speed and reduce human error.
- **Data Collection:** Computer Integrated Manufacturing Systems collect data during the entire production process. This includes data on machine performance, product quality, raw material inventory and more. This data is used to monitor and control the production process, and to make better decisions.
- **Data Processing:** In Computer Integrated Manufacturing, data collected from various sources is processed and analysed using computer software. This allows manufacturers to monitor plant performance in real-time, identify potential problems, and plan improvements.
- **System Integration:** Computer Integrated Manufacturing systems include the integration of various systems, such as production management systems (MES), quality monitoring systems, enterprise resource planning (ERP) systems, and other systems. This integration allows companies to coordinate all aspects of their operations more efficiently.
- **Production Flexibility:** With automation and computer systems in place, manufacturing companies can easily adjust their production processes to meet changing demands. This can include changes in the products being manufactured, the production volume required, or the configuration of production machinery.
- **Cost Reduction and Quality Improvement:** Computer Integrated Manufacturing can help reduce production costs by reducing human error, improving operational efficiency, and optimising resource usage. It can also improve product quality by more closely monitoring and controlling the entire production process.
- **Data Security:** In the context of Computer Integrated Manufacturing, it is important to secure data and systems from cyber security threats. Protection of sensitive data and system security are important factors in maintaining safe factory operations.
- **Product Innovation:** The integration of computer technology in manufacturing can support product innovation by enabling designers to create more sophisticated and complex products.

Computer Integrated Manufacturing is an evolution of the manufacturing industry centred on technology and data. By combining computers, automation, and data analytics, manufacturing companies can increase efficiency, reduce costs, and respond more quickly to market changes.

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C. Digital Systems

A digital system is a system that uses discrete representations, usually in the form of binary numbers (0 and 1), to process information. Digital systems are opposed to analogue systems that use continuous representations, such as electrical voltages that can vary within a certain range. Here are some important discussions about digital systems:

Discrete Representation: Digital systems represent information in a discrete form, which means the information is broken down into discrete elements. In the context of binary numbers, each piece of information can be represented as a string of 0's and 1's, where each digit represents a specific value.

Accuracy and Reproducibility: Digital systems tend to be more accurate and consistently reproducible compared to analogue systems. This is because digital values are not affected by small changes in the physical environment, such as temperature changes or electromagnetic interference.

Data Processing and Manipulation: Digital systems make it possible to perform various mathematical operations and data manipulation with ease. These include addition, subtraction, multiplication, division, and logic operations, which can be executed by computers and other digital devices.

- **Flexibility:** Digital systems can be changed easily by changing the software used, which is different from analogue systems that often require hardware changes for changes in function or application.
- **Signal Processing:** Digital systems are very useful in signal processing, such as audio and video. Analogue signals are first converted to digital form so that they can be better processed, stored and transferred.
- **Digital Communications:** Modern communication systems are almost entirely digital. Data is organised in digital packets, such as in internet protocols, and sent over digital networks, which allows for fast and reliable data transmission.
- **Ease of Storage:** Digital data can be stored on various media, such as hard drives, SSDs, memory cards, and cloud storage, which allows for efficient, fast, and accessible storage.
- **Data Security:** Digital systems also enable the implementation of strong encryption and data protection technologies, which can enhance the security of personal and business data.
- **Technology Development:** Advances in digital technology have opened the door for the development of various technologies, such as artificial intelligence (AI), Internet of Things (IoT) and cloud computing, which are changing the way we live, work and interact.
- **Challenges:** While digital systems have many advantages, there are also challenges to be faced, including cybersecurity, data privacy, and the environmental impact of using electronic devices.

Digital systems have become central to modern society, allowing us to communicate, access information, work and play in ways that were previously impossible. More and more sectors of human life rely on digital technologies, and an understanding of digital systems is becoming increasingly important in this changing world..

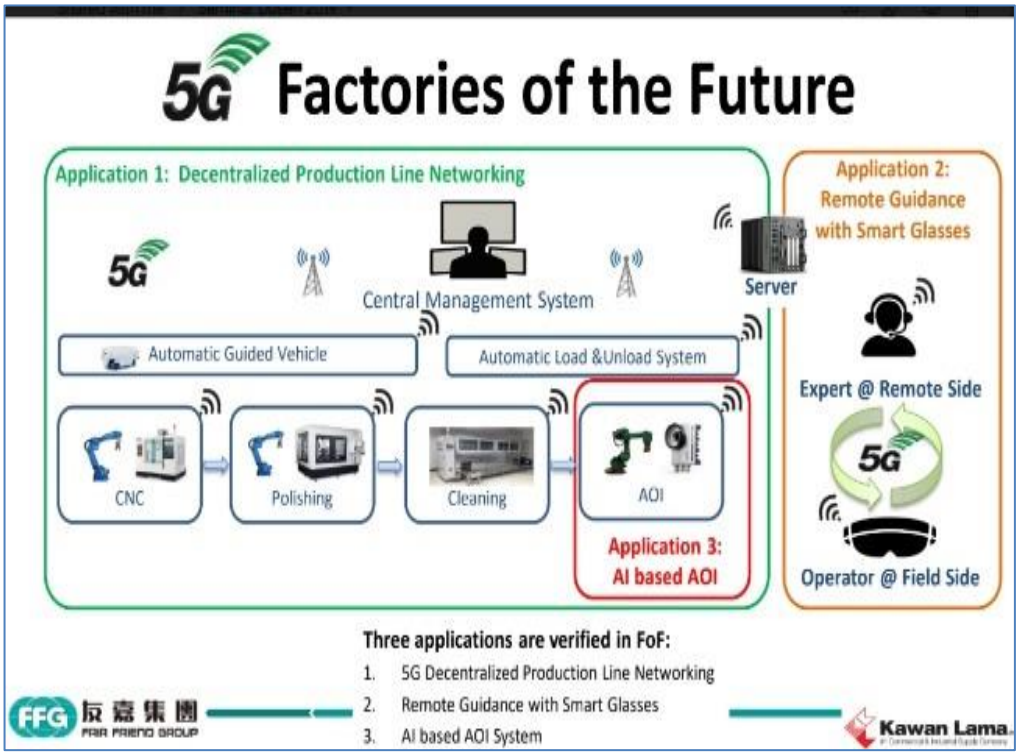

Fig. 2: Factories of the Future

ISSN No:-2456-2165

V. THE FUTURE WITH 5G TECHNOLOGY

5G technology is one of the latest innovations in the world of telecommunications and information technology. It is the fifth generation of mobile networks that is expected to change the way we communicate, access information, and interact with devices in the future. Here are some important aspects to consider in the discussion about the future with 5G technology:

A. Faster and Stable Internet Connection:

5G will provide much faster and more stable internet connections compared to previous technologies. Extremely high data download and upload speeds will enable uninterrupted streaming of 4K or 8K videos, as well as support other heavy applications and services.

B. Internet of Things (IoT):

5G will support the development of the Internet of Things (IoT) with greater capacity and extremely low latency. This will allow more connected devices, such as autonomous cars, smart home appliances, and industrial sensors, to communicate efficiently and provide data in real-time.

C. Augmented Reality (AR) and Virtual Reality (VR):

5G will open up great opportunities for the development of more advanced AR and VR. With 5G's fast connection and low latency, the experience of gaming, learning, or interacting with virtual worlds will become more realistic and immersive.

D. Telemedicine:

5G technology will enable the development of better telemedicine services. Doctors and patients will be able to communicate with high-quality video and transfer medical data quickly, which could be the key to more efficient and affordable healthcare.

E. Industry 4.0:

5G will play an important role in industrial transformation with better automation and remote control. This will increase productivity in various sectors, including manufacturing, agriculture, logistics, and energy.

F. Security and Privacy:

With increased connectivity, data security and privacy become more important. 5G will require special attention in data and network protection against cyber threats.

G. Required Infrastructure:

The implementation of 5G technology requires sophisticated infrastructure, including many widely connected 5G base stations. This requires substantial investment and co-operation between governments, service providers and technology companies.

H. Social and Economic Impact:

5G can have a significant impact on the economy and society as a whole. It can create new economic opportunities, but it can also raise questions about inequality of access and the rapid social impact of technology.

I. New Application Development:

The speed and capacity of 5G will drive the development of new applications that are currently difficult to imagine. Innovations in a variety of sectors, including entertainment, education, transport, and manufacturing, may emerge as a result of this technology.

It is important to note that the implementation of 5G technology also raises some concerns, such as health issues with respect to exposure to radio frequency waves and environmental issues related to infrastructure development. Therefore, there is a need for a balance between technological advancement and environmental protection and public health.In all, 5G technology has great potential to change the way we live and work, with a significant impact on various aspects of our lives in the future.

➢ *Factory operates without borders*

The factory of the future will be connected in almost every way, allowing for seamless operations in a variety of scenarios:

- Robotics, AI, and co-bots - The factory industry already uses robotics, but, in the factory of the future, these machines will be much more advanced and collaborative. As artificial intelligence continues to grow, processes such as design, predictive maintenance, and advanced programming will become more streamlined and instantaneous. Furthermore, AI will eventually develop the ability to follow the human way of thinking and be more creative;
- Virtual reality (VR) - Industrial training and education will become more comprehensive with the use of VR.

➢ *Integrated manufacturing system*

The Integrated Manufacturing System (IMS) concept is a concept that implements the design and manufacturing system in a management system. The goal is to be able to exchange data automatically. If the system is automated and linked as a whole in the Integrated Manufacturing System (IMS), it will be very beneficial compared to individual automated fuctions, such asindividual automated fuctions:

- Reduce lead time
- Increased flexibility in production capacity and production schedules
- Reduce labor requirements
- Reduce inventory levels of materials, work in process and finished products
- Improve resource utilization
- Flexible to changes in demand.

In the IMS concept, all basic manufacturing activities are automated and connected to each other. The basic manufacturing activities can be broadly divided into 3 parts, product design, manufacturing planning and manufacturing execution.

Product design. This activity involves defining the geometry of both part specifications and bills of materials (BOM). This design information is the key source of data to drive the manufacturing process.

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Manufacturing planning. This activity starts from planning both the tools and the capacity needed. After that, it plans the process where the results are in the form of process routes, operator instructions, tool control programs.

Manufacturing execution. This activity is the most tangible part of the manufacturing system. The main task is to control the process, tools and production schedule, which is all done by the technical and logistical data system. The performance of manufacturing operations is monitored and measured.

D. Implementation of Articial Intelligence in integrated manufacturing systems

Some applications of AI include:

- *Quality inspection*

Factories that make complex products, such as microchips and circuit boards, utilize artificial intelligence to check if there are errors in the product. The use of technology will certainly be more reliable than relying on the human eye. Usually here, AI services will be combined with high-resolution cameras. And when integrated with a cloud-based data processing framework, each error is flagged and a response to it is coordinated immediately.

- *Management*

LG's smart factories utilize machine learning to diagnose and predict defects in machines before they become a problem. This way, the management team can foresee unexpected delays as such issues can be costly for the company.

- *Designing faster*

Airbus utilizes AI to create thousands of component designs just by entering certain numbers into the computer. Generative design models allow Airbus to reduce the time Autodesk designers spend testing new designs.

- *Reducing impact on the environment*

The German company built a gas turbine with hundreds of sensors inside. Data from these sensors is fed into an AI-based data processing system. This intelligent system can regulate the fuel valves so that the turbine produces the lowest possible emissions.

- *Supply chain communication*

Materials company Firolabs pioneered the use of machine learning for predictive communication.

- *Leveraging data*

Hitachi pays close attention to the productivity and production levels of its factories. Previously unutilized data was collected and processed by AI systems to provide insights for the company.

- *Reducing waste*

A steel manufacturing company used predictive communication technology to reduce steel waste (mille scale). The company was able to reduce steel loss to 3%.

- *Integration*

Cloud-based machine learning, such as Azure Cognitive Services, allows the manufacturing sector to simplify communication between branches. Data in the production line can be inferred and shared with branch offices to mechanize material facilities, maintenance, and other operational activities that are still carried out manually.

- *Improving customer service*

Nokia pioneered the implementation of AI for customer service. This implementation allows Nokia to prioritize emerging issues and identify key customers and their complaints.

- *Providing post-production support*

A Finnish manufacturer of elevators and stairlifts uses a 24/7 Connected Services model to monitor how customers use its products and share that information with its clients. This allows Cohn to evaluate product faults and show clients how the products work evaluate product faults and show clients how the products work. show clients how the the product works

VI. CONCLUSIONS

The conclusions of research on the implementation of artificial intelligence in integrated manufacturing systems may vary depending on the results of the research conducted. However, here are some possible conclusions that can be drawn based on the research:

The implementation of artificial intelligence in integrated manufacturing systems can improve production efficiency by optimising production processes, inventory management, and production planning. This can result in increased productivity and cost savings.

Artificial intelligence can help in detecting and preventing product defects more efficiently. An integrated manufacturing system supported by artificial intelligence can ensure that products meet the set quality standards.

The implementation of artificial intelligence enables manufacturing systems to be more responsive to market changes and customer demands. With advanced data analysis, the system can identify market trends and organise production in real-time.

Manufacturing systems integrated with artificial intelligence can help in reducing downtime of production machinery and equipment by predicting the required maintenance before serious damage occurs.

Artificial intelligence can improve supply chain management by monitoring inventory, demand, and delivery in real-time. This can help in reducing costs and increasing efficiency.

Artificial intelligence implementations can provide management with better data and analyses, allowing them to make better and more informed decisions in managing manufacturing operations.Artificial intelligence can be used to strengthen security within a manufacturing environment

by detecting potential threats and taking preventative measures.

However, keep in mind that conclusions will depend on the results of each study. The implementation of artificial intelligence in integrated manufacturing systems can have varying impacts depending on many factors, including the specific industry, company, and technology implementation. In many cases, the implementation of artificial intelligence can bring significant benefits to companies in improving their efficiency and competitiveness in the market.

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