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Management 4.0: Concept, applications and advancements

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ABSTRACT

Management 4.0 assists businesses in evolving, surviving and performing in the competitive and dynamic world. This fourth revolution uses advanced technologies like Artificial Intelligence (AI), Virtual Reality (VR), Internet of Things (IoT), Robotics, Holography, Additive Manufacturing etc., for the proper management systems. These technologies facilitate working personnel and make it more appealing to complete their duties efficiently and accurately. The main aim of this paper is to understand the concept of Management 4.0, its technologies and applications for proper management systems. As Management 4.0 enhances process control, the chance of human error is reduced, leading to increased efficiency. It enables rapid and intelligent decision-making, reduces costs, accelerates growth, and raises profitability. Management 4.0 technologies and advanced data analytics are helpful to make smart supply chain management well suited to fulfil industry 4.0. Thus, to overcome various obstacles and effectively deploy Management 4.0 technologies in manufacturing industries, top management must establish a clear asset performance management plan with the help of process engineers familiar with industrial system failure occurrences and what operators need to improve. Management 4.0 involves advanced technologies, system connectivity, data collection & analysis at the organisation level. Management 4.0 is expected to be a critical component in the long-term survival of any business, either manufacturing or service-providing organisations. This paper explores the development of Management 4.0 and its dimensions and transformations through Management 4.0 perspectives. Finally, the significant role of Management 4.0 for appropriate private management system in manufacturing industries are identified. Organisations require a system that seamlessly meets the company's expectations, consumers, investors, and other stakeholders to remain competitive, and Management 4.0 will enable this. Many businesses strive to integrate technologies and upskill their personnel to adapt to the new job duties and attract more workers with the necessary abilities.

1. Introduction

Implementing Management 4.0 technologies provides firms with increased efficiency by connecting automation with data collecting and exchange protocols. Streamlining the procedures and boosting access to valuable data can optimise production with optimal resource utilisation. Advanced technologies are integral to Management 4.0, and their effective use could lead to better production and management. For instance, robots are an essential part of flexible automation and have many services in industrial manufacturing, including welding, assembling, plasma cutting, and finishing [1–3]. Manufacturers of all sizes may profit from robots in a variety of ways. Proper integration of Robots contributes to improved quality control, a safer work environment, decreased bottlenecks, higher output, enhanced worker satisfaction, and many more. Like this, a new factory is planned, and another powerful digital twin technology could be utilised for new products or processes. It allows for faster and more reliable innovation development with fewer physical prototypes. When a product is manufactured, or a factory is implemented, more data is generated to improve the Management 4.0 environment [4,5].

Management 4.0 envisages much-improved efficiency, productivity, and self-managing manufacturing processes in which people, machines, equipment, logistical systems, and work-in-process components directly connect, cooperate, and collaborate. The main objective is to use low-cost mass production efficiencies to enable make-to-order manufacturing of quantity one using embedded processing major communications [6,7]. Production and real-world performance data are gathered, evaluated, and returned to development. Companies have already acknowledged that their most valuable asset is people, with the typical human re-

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sources department trending toward strategic people management. They also realised that the technology they produced or could simply and affordably buy from other parties might be used to automate organisational processes. The Digital revolution increasingly embraces internet tools, techniques, services, and HR departments [8,9].

Several management activities are aided by innovative virtual solutions and resources that automate manual procedures and optimise strategic duties. Management 4.0 systems collect a large amount of data that may be utilised to improve performance and productivity through analytics. Real-time predictive maintenance helps manufacturing organisations prevent production interruptions caused by equipment breakdowns on the factory floor, enhancing asset utilisation [10,11]—optimising industrial activities, which improves productivity and energy efficiency. Manufacturers may now construct digital twins, virtual clones of processes, manufacturing lines, factories, and supply networks. Data from IoT sensors, gadgets, PLCs, and other internet-connected things is used to construct a digital twin. Digital twins can help manufacturers enhance efficiency, optimise operations, and create innovative products. Manufacturers can evaluate the process modifications by simulating to identify methods to reduce downtime or increase capacity. Management success relies on adopting new technologies during periods of great innovation [12–14].

This unique management revolution does not need a huge investment or a comprehensive Industrial Internet of Things framework. This provides the essential information needed to apply just-in-time corrections sequentially and deliver targeted information and operational advice to line workers in a convenient and straightforward format. It is about maintaining the workforce's efficient workflow, developed over a decade and giving real-time, contextual instructions to guarantee that the operation fulfils specifications and objectives. Management 4.0 is most closely associated with applicability and general comprehension management. As a result, this is seeing unprecedented growth and development. The internet of things, cloud technology, advanced computers, robotics, and humans are all driving the expansion of automation and data technology. Integrating software, equipment, and people effectively improves the speed, dependability, and data flow across many systems [15–17]. This study provides an overview of Management 4.0 and its potential for a proper management system.

2. Management 4.0

Management 4.0 revolve around several emerging concepts, including smart manufacturing, smart industry, interconnected industry, and cyber industry. These terms indicate the application of technology to make the production process more agile, adaptable, and visible to consumers. This entails the digital transformation of the industry, which includes integrating and digitising all industrial processes that make up the value chain, characterised by adaptability, flexibility, and efficiency, allowing it to meet customers' expectations in the present market [18–20]. Management 4.0 represents a quantum leap in the organisation and management of the whole value chain throughout the manufacturing and distribution of a product's life cycle. Management transformed through new technologies, business models, and societal changes. Digital methods for Quality Management (QM) are becoming essential by employing sophisticated analytics and automation technologies in Management 4.0. Digitalisation helps achieve higher efficiency robustness and delivers an immediate and enduring effect. QM can be a successful driver on the road to technological advancement [21,22].

Management 4.0 is a collection of digital technologies ranging from connection to sophisticated analytics, robots, and automation, transforming the organisation and creating an agile culture. Furthermore, it establishes the theoretical underpinning of agile concepts, fully comprehending and analysing the value of all expert suggestions [23–25]. The enhanced cloud capacity, adaptability, and cost-effectiveness for data analytics are significant corporate benefits. Predictive measurements may be used to handle changing business realities. In addition, Machine Learning is applied to fine-tune the system to keep up with ongoing changes in products and processes. MES models may be updated regularly to improve throughput, quality, yields, and uptime using predictive and prescriptive analytics. This is to achieve plant-wide and business-based requirements, such as equipment utilisation targets or customer-requested delivery schedules [26,27].

3. Need of Management 4.0

There is still a human aspect to supply chain management, evolving in the decentralising setting of Management 4.0. However, there is a need for a digital management system and operations to fulfil the requirements of Management 4.0, an automated, intelligent, and more autonomous flow of assets, products, materials, equipment, and information between the point of origin and the point of consumption. Exponential technological advancements lead to more complicated relationships [28,29]. As organisations compete in the global market, work processes are speeding up, multidisciplinary ties between departments are growing, information flows faster, and link expansion has become regular. These advancements motivate organisations to develop the Management 4.0 culture. It also enables more robust connectivity inside the organisation, optimising the entire value chain and enriching working spaces.

Further, Management 4.0 is to keep the trend of decreased manufacturing costs, even when there are a lot of them. For years, lean ideas paired with more automation have resulted in economical prices. AR, robotics, IIoT, mobile, and cloud are examples of Management technologies that help eliminate the need for people to undertake repetitive tasks. The use of digital management tools such as data mining allows gathering and evaluating the data created by furnaces continuously, as measured by sensors, flow meters, and other devices [30–32]. The significant research gap in the literature review is in understanding how Management 4.0 is helpful for data-driven management systems.

4. Research objectives

Management 4.0 technologies provide insights into operations and business processes, allowing visibility, predictability, and automation. Businesses may use data from various machines and devices to undertake predictive maintenance using machine learning algorithms, resulting in increased uptime and efficiency. These needs real-time manufacturing; some data analysis must be performed at the edge, generated by the data. This reduces the time between when data is generated and when a response is required. Detecting a safety or quality issue with equipment may necessitate near-real-time response [33,34]. The time it takes to transport data to the business cloud and back to the manufacturing floor might be excessive and depend on network stability. Cybersecurity and cyber-physical systems have not always been a priority for manufacturing businesses. However, the factory connection that allows for more efficient operations also opens up new entry points for harmful attacks of viruses. It is critical to adopt a cybersecurity solution that includes IT and OT equipment while conducting a digital transformation to Management 4.0 [35,36]. The primary research objectives of this article are as under:

- **RO1: -** to brief Management 4.0 and explore its need in the best management of systems through the contemporary literature;
- **RO2: -** to discuss dimensions of Versatile Revolutions being bought through Management 4.0 Perspectives;
- **RO3: -** to study significant transformations through adopting Management 4.0 strategies;
- **RO4: -** to identify and discuss the significant role of Management 4.0 for proper management of manufacturing industries.

Fig. 1. Different domains of revolutions that can be bought through adopting a culture of Management 4.0.

5. Dimensions of versatile revolutions through the perspectives of Management 4.0

Several revolutions have been reported to create an influential culture by providing a base for different courses with a basic understanding of Management 4.0 culture and fundamentals. It is entirely based on the ideas and structures of Industry 4.0 strategies and their implementation in the management platforms, as explored in Fig. 1. It broadly explores consumer-related, energy, agriculture, travel, tour-based, etc. The philosophy of Management 4.0 has thoroughly changed the strategic working of these elaborated revolutions and proposed an excellent base for further growth and progress [37–39].

The manufacturing industry is undergoing a revolution due to Management 4.0 technology. Data quality and networked data-sharing systems will impact quality management, ranging from accelerated improvement and cutting quality costs to driving skill changes. Quality professionals must study, promote, and implement new advances into their processes to remain competitive. Integrated sensors and the Industrial Internet of Things (IIoT) could be used to their full potential [40,41]. Many businesses have begun their deployment by establishing data collecting infrastructures and installing CPS systems and IoT devices on the shop floor. Asset management, predictive maintenance, and quality control are some operational use cases.

Manufacturers utilise the large amounts of storage space necessary to physically store the massive amounts of data generated by Industry 4.0 operations. Cloud computing enables a single source of reality and rapid data exchange across the organisations and value chain. This also allows remote access and management of all data and machine operating systems which helps increase visibility and efficiency [42–44].

The design of an intelligent factory's network relies heavily on interconnectivity. Data collected over time from factory sensors, devices, and machines can be immediately consumed, used by other manufacturing assets, and shared across other corporate software stack components like enterprise resource planning and other business management software. Smart factories can generate more cost-effectively personalised items that fit the demands of individual clients. It leads to more income and better customer service and satisfaction. Manufacturers can realise the value of the connected factory when getting the most out of their production with sensor-monitored machinery while providing individualised attention and quick support to consumers via AI and field service. Professionals now have other demands, and many receive employment offers from other organisations. It is crucial to strive for the best experience, making the work environment more appealing and less monotonous for generations born immersed in technology; having it present in their day-to-day job is critical [45–48].

The role of Humans in Management 4.0 advances from machine operator to problem solver and decision-maker. Assistance systems are intended to assist operators who make quick judgments to handle critical difficulties. Innovative technologies like cloud computing, big data analytics, IoT, and even Artificial Intelligence can now link machines, sensors, and other devices to the personnel entrusted with the monitoring process for efficacy and efficiency. Sensors with IP addresses are installed on the manufacturing floor, allowing the machines to communicate with other web-enabled equipment. Large volumes of essential data can be collected, analysed, and distributed to mechanisation and connectedness. Any Management 4.0 plan must include cloud computing. Engineering, supply chain, production, sales and distribution, and service must be connected and integrated for intelligent manufacturing to be fully realised [49–51].

6. Significant transformations achieved through Management 4.0 strategies

The various transformations have been observed with the supportive practices of the Management 4.0 scheme in different dimensions. Some significant highlights of changes through Management 4.0 as reflected in Fig. 2. The overall development of the industrial issues are named as; changes in technology with the innovations like machine learning and artificial intelligence, issues of societal improvements, general work patterns transformations, leadership transformations with the provision of command and control of style and management throughout, and business transformations for the progressive development of industry practices as a whole [52–56].

Cloud computing allows for more efficient and cost-effective processing of the vast amounts of data stored and analysed. Small and medium-sized manufacturers can also save money using cloud computing since they can predict their demands and scale as their firm grows. Manufacturing businesses may use AI and machine learning to fully use the abundance of data created on the factory floor and throughout their business divisions and partners [56–59]. An employee can access essential processing steps while avoiding potential damage using headset technology such as those on the inspection line. Furthermore, as predictive maintenance advances and becomes more widely adopted, augmented reality may be utilised to assist with machine inspections and, in certain situations, maintenance jobs. The IoT is concerned with machine connection, smart manufacturing, and operational efficiency. The IoT links vital machinery and precise sensors in high-tech sectors, including geolocation technology, and creates extensive data. The industrial sector's communication-based ecosystem brings together people, analytics, and smart equipment to make gathering, analysing, sharing, and monitoring actionable data easier [60–63].

Businesses must have essential things to deploy, as Management 4.0 technologies are: critical engineering and technological knowledge and experiences, access to the relevant vendors for devices such as sensors and machines, and sophisticated analytics and data science capabilities. The obtained data must be integrated, organised, and artificial intelligence enriched. It allows for better knowledge of various resources/machines for problem detection, failure prediction, and optimisation operations such as service order management and planning [64–67]. Engineers will be compelled to become practical engineers due to Management 4.0. The adoption of Management 4.0 will necessitate the presence of professional engineers at the facility. A practising engineer is a multitasking professional who applies technical expertise, employs world-class production tools and procedures, and learns data analytics to comprehend and analyse trends to identify the most cost-effective solutions. Engineers and executives must take the role of facil-

Fig. 2. Significant transformations through Management 4.0 adoptions.

itators in the connected enterprise. Management 4.0 provides a greater degree of assurance of quality. Blockchain technology can help protect all data related to the product, sub-assemblies, components, and distribution path to market [68–71].

7. Role of Management 4.0 for enhancing the performance of the system of manufacturing industries

Management 4.0 alters production logistics and shifts the demands on logistics providers. There are several forms of logistics and numerous definitions of logistics, ranging from the organisation, planning, and administration of a complicated task, such as the logistics of setting up an event, to activities involving numerous moving components and processes [72–75]. Management 4.0 is also vital for Industrial Data Space to enable safe data sharing amongst its participants while simultaneously preserving data. The Industrial Data Space is one strategy that the proponents of Management 4.0 have pushed hard. The prospects of blockchain technology in supply chain management and hyper-connected and autonomous logistics have been explored in the future of logistics. The number of blockchain efforts in logistics is rapidly increasing, as are many critical consortiums [76–79]. The significant role of Management 4.0 in a proper management system in manufacturing industries is discussed in Table 1.

Machine Learning systems sift through massive sensor data to spot anomalies or deviations. The Artificial Intelligence algorithms provide a baseline for permissible sensor behaviour deviations. When the number of acceptable deviations exceeds a certain threshold, an alert of impending deterioration or malfunction is created and transmitted to the facility maintenance team. Because of machine learning, scheduling maintenance chores will be decreased, allowing resources to be allocated to other areas [202–204]. Machine learning will be utilised in the Hybrid Smart Factory to discover aberrant and associated patterns of sensor activity to detect machine deterioration or defect before it occurs. Traditional asset monitoring systems will continue to require high-priority sensors that must be monitored for strategic or operational reasons [205–207].

8. Discussion

The effective adoption of advanced technologies is critical to the transition to Management 4.0. Digital twins of machines and operations and factory automation, and real-time control of equipment and jobs will be required to accelerate smart manufacturing. Management 4.0 provides a significant level of openness within the digital supply chain management environment. Simultaneously, it enables smooth data interchange between suppliers, vendors, and warehouse managers to eliminate potential inconsistencies. The deployment of IoT sensors allows for real-time asset tracking, which helps warehouse management procedures run more smoothly.

Additionally, cloud-based dashboards allow businesses to oversee various warehouse and supply chain activities from a single location. Management 4.0 proposes a more holistic, integrated production strategy. It connects the real and digital worlds and improves the quality of cross-departmental communication. As a result, Management 4.0 assists business owners in efficiently optimising their operations. Based on this, we proposed a comprehensive definition of Management 4.0 as follows:

> "Management 4.0 is creating and operationalising a digital environment through the effective integration of Industry 4.0 technologies, data, and knowledge, enabling high coordination & control amongst the different activities and working personnel in business organisation to create and enhance value."

This definition focus on the three significant aspects: industry 4.0 technologies, data and knowledge. These three interconnected compo-

Table 1
Role of Management 4.0 for developing the proper management system.

S No	Applications area	Brief description	References
1	Open up enormous possibilities for change	A specialised set of digital quality management technologies may reduce costs and open up enormous possibilities for change. Manufacturing companies must incorporate and leverage dimensions in their operations to become more digitised, automated, and distributed. All possibilities are a digitally enabled production and quality feedback loop, AI-based quality testing, vision control, and a fully automated, real-time production and quality control tower. It lowers overall performance in labour-intensive processes and related businesses, where production is frequently disrupted. These labour shortages are also due to a lack of training, unoptimised processes, a higher rework rate, and a higher scrap rate.	[80–85]
2	Inspection and quality control	Manual inspections, which often require many inspectors and associated time, are another problem for quality systems. While quality checks are essential for assuring product specification, they can also offer security due to undetected faults and human mistakes on the production line, combining a testing-and-vision control system with an ML-based process. In real-time, one can discover operator mistakes, quality deviations, and process variances. Advanced analytics and real-time process verification are used in digitally-enabled production-and-quality feedback loops to analyse trends, avoid variations or out-of-spec production, optimise rework, and remove bottlenecks faster. The feedback loop converts work processes into visual advice and quality checks using digital tools that are simple and comprehensible for operators and supervisors.	[86–89]
3	Digitisation	Successful implementation of Management 4.0 encourages a company's digitisation and long-term growth. As a result, it strengthens new ideas, shapes leadership styles, and facilitates restructuring processes and management. As networking and cooperative work grow relevant, Management 4.0 becomes essential as a natural step up. Thus, to include the complicated process, stepwise mitigation is essential. In terms of Management 4.0, this goes beyond technical training to encompass sensitisation to change and new working methods. To avoid a sudden change, schedule time for staff sensitisation. Therefore, working personnel will be less resistant to new structures, and employees will be more actively engaged in the company's restructuring.	[90–96]
4	Creating a new working environment	Upgrading to Management 4.0 necessitates new working methods, and, as a result, a new working environment is required. Internalising and transmitting the ideals of corporate Management 4.0 to all sectors of the firm is essential to creating the required working environment. Please take advantage of agile management techniques and promote their implementation. A successful Management 4.0 strategy must go beyond mere plan execution. Communication skills are required to properly implement change and prepare the firm for future responsibilities that will lead it to wealth. More precisely, this implies that change must be communicated inside the organisation to allow people to accept the change and see it as an opportunity.	[97–102]
5	Embracing smart factories	Industrial facilities that have embraced the intelligent factory vision like the notion of creating a virtual replica of a machine that can be monitored in real-time. At the same time, adopting the digital twin faces considerable challenges. Deployment expenditure is the most prominent barrier to implementing the digital twin in their production setting. The digital twin can give vital real-time information about a machine's functioning. It can be utilised for select high-priority, high-cost equipment at best. The digital twin idea is not economically viable for many production verticals and facilities. Because vast volumes of sensor data can be evaluated in real-time, Automated machine learning represents a quantum leap in data science. AI supervises the selection and application of machine learning models to datasets in automated machine learning. Automated machine learning enhances the speed and accuracy of data insights by allowing AI to handle the model application process.	[103–108]
6	Digital communication	Digital communication is a significant force in the evolution of industry dynamics. Information can be exchanged, and cooperation is organised more quickly and efficiently than in the old analogue culture. Digital technologies have the power to store information, resulting in perpetual responsibility. Scaled agile Management 4.0 combines ideas into an agile scaling meta-framework. Digitisation is an environment that modifies this macro-structure, resulting in interaction patterns that are unique to digitisation. Technology has revolutionised how we consume and relate to data in many aspects of our lives. It has made information access faster, resulting in a shift in how to consume and relate to data. The business world is becoming increasingly entangled in this ever-changing technology landscape. Automation and connectivity have increasingly become more prevalent in the industrial sector.	[109–114]
7	Improving the operational efficiency	Digital technologies are used in Industry 4.0 to respond more swiftly to market changes, deliver more customised goods, and improve operational efficiency. All manufacturing elements must communicate, including cyber-physical systems, robots, corporate information systems, smart goods, and people. The ability to build autonomous sub-processes inside manufacturing using cyber-physical elements can make decisions independently. The capacity to gather and analyse massive volumes of data to monitor, regulate, and optimise processes and facilitate any outcome or decision produced from the process at any point in time. It supports the creation of the capacity of a virtual duplicate of fabric by gathering data and modelling industrial processes, resulting in virtual plant and simulation models. With new disruptive business models, the capacity to transfer the new value gained to the consumer in new or enhanced services.	[115–119]
8	Proper distributions of goods	Management 4.0 is changing how businesses make and adequately distribute their goods. Advanced sensors, embedded software, and robots are used in these smart factories to gather and analyse data, allowing better decision-making. When data from manufacturing operations are coupled with operational data from ERP, supply chain, customer service, and other business systems, new visibility and insight are produced from previously isolated data. The manufacturing industry has an excellent opportunity to enter the fourth industrial revolution by establishing smart factories. Analysing massive amounts of big data collected from industrial sensors allows a real-time picture of production assets and predictive maintenance solutions to save downtime. Introducing high-tech IoT devices in smart factories has enhanced production and improved quality.	[120–123]
9	Information transparency	A smart factory may achieve information transparency and better decision-making by gathering more data from the manufacturing shop floor and linking it with other companies operating data. Using AI-powered visual insights to replace manual inspection business models decreases production mistakes and saves money and time. Quality control staff may set up a smartphone connected to the cloud with minimum expense to monitor production operations from remote locations. Manufacturers can spot mistakes by using machine learning algorithms. Informed data helps manufacture products more effectively and productively across the value chain, as seen by increased automation, smart equipment, and smart factories. Manufacturers' flexibility is enhanced to satisfy consumer expectations through mass customisation, eventually aiming for efficiency with a large size in many circumstances.	[124–128]
10	Supply chain management	As part of a comprehensive Management 4.0 plan, industrial operations rely on transparent, efficient supply chain management connected with production processes. It significantly impacts how manufacturers get raw materials and deliver completed goods. Manufacturers can better organise delivery by sharing relevant manufacturing data with their suppliers. Industry 4.0 is based on the concept that machines should interact with one another and collaborate to produce new goods and services. These solutions are already transforming our lives and work and significantly influencing the global economy. This new production age combines technology, robots, AI, and automation to produce a more efficient and effective manufacturing process. The investment in new technologies, such as digital solutions that revolutionise physical operations, must maintain the organisation's advantages at the centre of the plan.	[129–132]
11	Enhance safety	Factories may achieve better productivity and efficiency, higher quality and output, and enhanced safety by implementing Management 4.0 through digital transformation across lines, assemblies, plants, and factories. Improved machine monitoring via industrial connection implies less unplanned downtime due to unanticipated events, increasing overall equipment effectiveness. Increased machine efficiency can result in faster changeovers, which helps accelerate the launch of new products. Using Management 4.0 technology to break down the conventional silos that operate manufacturing operations can assist boost cooperation and information sharing, allowing to be more agile and flexible. All manufacturing industries are being restructured by digital transformation.	[133–137]

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Table 1 (*continued*)

S No	Applications area	Brief description	References
12	Detecting faults	The system analyses data from several cameras uses deep learning models to detect faults and deviations and functions as a digital assistant by alerting the operator to problems and giving directions on how to resolve them. The Artificial Intelligence-based vision control system also feeds into a digital twin, giving real-time data to industrial engineering, production planning, and quality management. Several assembly-based enterprises with manual activities and procedures have implemented in-station automated production and quality control systems that have significantly lowered rework rates by providing rapid, real-time feedback to workers, thereby avoiding many downstream concerns. It includes shorter cycle times owing to automated flaw identification and less reliance on downstream manual inspection at the end of the line. These systems can also give insight into lean improvement metrics, productivity gains, and efficacy.	[138–142]
13	Monitoring of Real-time operations	Real-time operations monitoring, from single production stations to multi-plant operations, enables speedy discovery of deviations, issue solutions, and decision-making. It involves advanced analytics-based alarms, performance trend prediction, and actionable improvement insights to keep more significant quality concerns from escalating upstream. A global top component supplier created a manufacturing and quality-control tower to ensure product and process quality from product creation to final product delivery. Even the most senior production and quality managers have limited real-time information and visibility into operations and quality performance in a single plant or across many facilities.	[143–147]
14	Remote Management	Management 4.0 technologies enable data to be retained and stored in the cloud, an online environment where resources may be accessed and controlled through the internet. This aids in the optimisation of structure and storage costs, as well as allows for remote management. It allows for theft prevention and protection against damage to hardware, software, or electronic data, giving enterprises a higher level of security. Cameras, displays, and GPS allow virtual information to interact with the actual world, allowing for 3D process simulations and early detection of faults. IoT-enabled technology would allow manufacturers to have complete insight into their operations. This system can handle everything from raw material purchases to inventory management and production analysis.	[148–152]
15	Higher flexibility in managing operations	Management 4.0 enables more flexibility in managing industrial operations, resulting in higher asset utilisation. As a result, the possibility for increased income. Autonomous mobile robots can do low-value jobs like product delivery, freeing up experienced human employees to focus on higher-value duties. One of the most significant advantages of IoT solutions on the production floor is worker safety. Thus to maintain a safe and healthy working environment, sensors are deployed on-site and worn by workers. The skillset of many factory workers is being expanded due to Management 4.0. Workers are acquiring new abilities to boost operational efficiency and skill sets when new technology is introduced into the operation. Management 4.0 is comprehensive automation that aims to increase industry efficiency by integrating all areas of production and commerce beyond corporate borders.	[153–156]
16	Synchronous manufacturing	Traditional assembly lines follow processes based on manufacturing work orders completed through corporate business systems. Each manufacturing station syncs with the assembly line and gets production steps from a central location. Industry 4.0 is based on synchronous manufacturing, with auto-identification technology used by components in the production flow to instruct each machine and operator. There is the usage of innovative, flexible machines that could adjust to the needs of the product. It results in a highly lean, flexible, and agile manufacturing process that allows the manufacturing of a range of products. Due to the ability to quickly adjust equipment to conform to customer-supplied requirements, advanced manufacturing technologies allows the manufacturing of customised products.	[157–160]
17	Enhancing customer satisfaction and customer delight	Manufacturers and the service channel can enhance customer satisfaction and time-to-repair metrics using field service based on product performance data. Remote diagnosis, monitoring, and repairing of linked items improve customer loyalty, provide value, and help manufacturers maintain product quality requirements. Actual product performance is documented, early warning and detection signals are created, and closed-loop feedback promotes quality improvements in future goods. The openness provided by Management 4.0 technology offers operators a considerable amount of data that will help them to make informed decisions. Interconnectivity enables operators to collect massive volumes of data and information from all points in the production process, improving functionality and discovering critical areas where innovation and improvement may be made. Operators may make choices both within and outside production facilities because of interconnection and information openness—this capacity to bring together aids in better decision-making and overall productivity.	[161–164]
18	Facilitating good consumer connections	Management 4.0 can also influence production by facilitating good consumer connections. Technology, data, and information that may assist in revolutionising industrial operations can also improve the responsiveness of processes and systems to consumer demands. Interconnected technologies' unique characteristics enable manufacturers to respond and adapt to customer needs more rapidly and even produce custom orders with less effort and setup time than traditional production. Manufacturing processes constantly change, resulting in leaner production and more efficient procedures. This can guarantee that processes produce the required information to guide improvements and optimal performance, keeping ahead of the management 4.0 technology and strategy competition. Many technologies of management 4.0 components are already in place, which connect machines, processes, and products.	[165–169]
19	Automate data analysis	Another strategy to boost the facility's production is to automate data analysis. The use of sensors to monitor equipment allows data to be. As a result, the software can forecast when maintenance is necessary with greater accuracy. Furthermore, keeping track of the metrics associated with processes simplifies these duties and makes better long-term strategic decisions. Augmented reality has seen a rise in popularity across all industrial industries. While these technologies are still growing and safeguarding the worker, health and safety are thought to significantly affect overall safety, particularly people and sanitation requirements. Management 4.0 connects portions of a process that formerly relied on human communication, allowing users to gather, analyse, and use data in real time. Technologies enable predictive and prescriptive maintenance on industrial assets, considerably improving human operator performance and enhancing production flexibility.	[170–173]
20	Boost revenue growth	Management 4.0 can boost revenue growth, corporate processes, supply chain, product, and consumer expectations. It covers a considerably larger spectrum of businesses and areas. Technology combined with Management 4.0 can create whole new services and products. Using portable devices and sensors, robots, and analysis will enable product innovations, from developing testing and prototypes to connecting previously separated items. It is about fundamental changes to how things are done in the industry. There are new manufacturing industries and new production techniques with the latest technology. Self-service analytics in engineering can aid in the consolidation of massive amounts of big data from manufacturing plants. It offers smart industrial equipment that transmits real-time data to an extensive data analytics system. The self-service technology then dissects the real-time data, identifies trends, detects flaws, and analyses essential decision-makers information.	[174–176]
21	Preventative maintenance	Managing machine networks, event automation, and preventative maintenance are all significant components of Management 4.0. Real-time processing of complex data from many sources makes this feasible. Preventative maintenance enables prompt interventions, reducing the expense and recovery time associated with delayed reactions. Users are empowered to make rational decisions based on real-time data in the proper context, saving organisations time, money, and resources. Management 4.0 is making progress in the corporate sector. This revolution advances constantly push the limit, from biotechnology to artificial intelligence. Human life and intellect are constantly redefined, and this trend will continue.	[177–179]

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Table 1 (*continued*)

S No	Applications area	Brief description	References
22	Powerful document management system	An easy-to-use and powerful document management system is one of the most excellent methods to succeed with Management 4.0. This system should help stay informed while monitoring various types of data and information about workplace procedures, sub-processes, functions, and technology. Regardless of their title or position in the business, all workers must have access to and knowledge of responsibility, reporting, and monitoring. Simulation technology allows virtual clones of real-world machinery, objects, and people to be created. The real benefit of simulators in product development, material research, and manufacturing processes is that they allow testing and improve machine settings for a product before deploying the same in the real world. In this way, the simulation may aid in reducing failures in any manufacturing process, as well as the assurance of quality and the reduction of setup times for the actual machining process.	[180–182]
23	Collection of critical machine data	Management 4.0 allows collecting critical machine data, which can be analysed using machine learning systems. Wearables or mobile devices on the plant floor can alert workers in the event of a crisis. One of the numerous benefits of Management 4.0 is that it makes information more accessible. The emergence of Management 4.0 will revolutionise asset management, from how technicians conduct day-to-day operations to how plant managers set up their facilities. The most crucial initial step in building the Management 4.0 vision is to recognise the used cases and identify enterprise-wide business drivers. It should, however, be accompanied by knowledge of how it will affect personnel, manufacturing processes, and the requirement for new technology implementation, integration, and management. Before implementing Management 4.0 technologies and capabilities, manufacturers should have a compelling, tailored storey for their business that outlines the common purpose and argument for change and the employee-centred vision.	[183–186]
24	Increase overall profitability and competitiveness	Management 4.0 methods may assist enterprises in gaining insights and optimising all areas of their production processes and supply chains, increasing their overall profitability and competitiveness. Technology is continually evolving, and some trends should be aware of to shape and adapt the company to keep up with the times. Business software digital assistants will intelligently classify spending and follow up on invoices automatically, freeing time to focus on serving customers and developing business. Manufacturers in various sectors have a significant chance of taking advantage of technology and improving their operations. This examines an end-to-end strategy that integrates people, processes, technology, and data to reach that goal, which real business drivers dictate genuinely. Early agile adoption allows for a unified programme structure and delivery, current technological solutions and capabilities, workforce buy-in for adoption and development, and compelling value propositions with a clear realisation path.	[187–189]
25	Enhancing the efficiency of the lean process	Combining conventional lean methods with Management 4.0 enhances the speed and efficiency of the lean process while also allowing firms to capitalise on the initial momentum provided by traditional tools. Management 4.0 technologies are beneficial in that they supply more than simply data. However, they also evaluate the data and get essential insights from which choices compatible with classic lean may be made. Smart machines will get smarter, factories will become more efficient, processes will become less wasteful, manufacturing lines will become more flexible, and productivity will increase. There are chances to prolong machine life through predictive maintenance, facilitate speedy material handling, monitor every element of the shop floor, and exploit collaborative robots concurrently with mobile communication, all built on smart, secure, and wireless connections.	[190–192]
26	Making resilient organisation	Businesses may establish the groundwork for long-term resilience to future crises by using Management 4.0. Organisations act to keep up with digital change, from updating supply chains to addressing cybersecurity. More job and learning opportunities will be available due to an open 5 G network, which is wireless, software-based, and automated rather than relying on legacy systems. It will result in a more diversified and technologically adaptable global workforce. It has prompted businesses to reconsider everything about their companies, from products and services to operations and delivery approaches. Organisations have depended extensively on technology to design new offerings, communicate globally and internally, and provide goods and services. Systems based on exponential technologies can assist businesses in creating more innovative supply chains and improving their digital resilience. Supply chains utilising AI and other emerging technologies can help businesses sustain business continuity.	[193–196]
27	Enabling the adoption of smart technologies	Management 4.0 helps enable the adoption of smart technologies. It encourages the creation of new product developers, resulting in more market competition. IoT is dealing with the advent of innovations, such as increased efficiency of data monitoring techniques. It is driving businesses to concentrate on more robust and innovative products. The use of IoT in smart manufacturing allows for the collection of intelligent data from systems, which is coupled with contextual data. IoT allows for remote monitoring and process management of data and real-time changes to production plans. Connected smart systems can transmit essential data to manufacturing systems in real time, enabling the detection and correction of process steps. These smart connected devices provide new possibilities regarding functionality, reliability, product use, and capabilities that cut over and exceed traditional product boundaries.	[197–201]

nents are essential for the realisation of Management 4.0. With the adoption of industry 4.0 technologies, data could be collated and analysed. Data analysis creates knowledge that is useful for making the proper decision. Based on the knowledge, more autonomous and agile production could be achieved. Management 4.0 technologies present fundamentally new issues in the interplay between man and machine.

Further, these technologies help to develop better coordination and control amongst the people and processes. Consequently, businesses are made more efficient as waste generation, reduce mistakes, streamline operations and create more value. The technologies of Management 4.0 emerged gradually, just like any other societal progression. The new industry allows for more flexible manufacturing and customisation options. Management 4.0 provides real-time device, machine, and data monitoring, allowing for faster detection of faults and more precise monitoring. Various activities are automated because of innovative technologies like the IoT, big data, and artificial intelligence, resulting in more efficient and lean teams. Cutting-edge technology is changing traditional human resources. Management 4.0 marks a significant shift in how businesses approach production, and it is also true that this shift has decreased the need for human resources, mainly through automation. Similarly, data transmission across systems has drastically improved efficiency and decision-making processes in human resource management. These data could be stored and transmitted over the blockchain network more securely [208,209].

The ultimate purpose of a connected factory is to increase efficiency and, thereby, revenues. Automation must be implemented in some or all production processes to achieve this. The interconnectedness and communication across a Management 4.0 optimised facility enable automation via robots and Artificial Intelligence. There are many of data to sort through because every function of the manufacturing operation is monitored and generates data. For industrial organisations, embedded sensors and associated machinery generate actual big data. Manufacturers may use data analytics to study previous trends, spot patterns, and make smarter decisions. It will give them more profound insights, where smart factories may combine data from other company sections and their broader ecosystem of suppliers and distributors. Manufacturers can make production decisions based on sales margins and personnel by observing human resources, sales, and warehousing data.

9. Conclusion

Management 4.0 technologies help connect machines to the cloud and construct customised versions of their industrial IoT. These technologies are laying the groundwork for future development and scalability. The ultimate objective of Management 4.0 is to enhance and advance industrial processes. In recent years, the manufacturing business has undergone many changes. Management 4.0 is a comprehensive and unified set of technologies that can transform the entire management system. It has also become a reality in which factory automation is commonplace, and factories are more intelligent than ever before. Technologies aim to collect massive volumes of data from various sources. These provide intelligent production scheduling software, the foundation for smart autonomous decision-making. In this Management 4.0 scenario, supply chain analytics will reach new heights. Manufacturing as a service allows firms to bid on manufacturing a product or a single production step. This specialisation can improve manufacturing efficiency while lowering costs and fine-tuning the supply chain. Production and logistics operations are smartly connected, resulting in a more efficient and adaptable real-time lean manufacturing environment. This will make it easier to build smart value-creation chains that span the whole product life cycle, from conception to manufacture, usage, and maintenance to recycling. These characteristics of the Management 4.0 facilitates the managers to make data-driven decisions and set their strategic goal in that direction. Management 4.0 enabled culture to help the employee develop their own skill set that might help make the process and operations more efficient. The primary role of Management 4.0 is to motivate the managers to develop the Management 4.0 culture. In addition, Management 4.0 technologies will become extremely useful in the manufacturing process and assist with various logistics, including manufacturing, production, and shipping. This study might be helpful for proper management systems in the industries and provide proper information systems.

Organisations with finite resources safeguard and conserve resources while also developing new business models or shifting current business models toward more sustainable resourcing models that might result in more profitable outcomes in the future. Digitalisation will be the key to assisting businesses in achieving long-term sustainability goals while improving overall performance. Employers will profit by using focused methods and incorporating videos to attract potential future workers. A mix of enticing visual aids and useful, target-orientated information distinguishes well-produced videos. In a sea of generic textual job postings, a video distinguishes itself and is firm by speaking directly to prospective applicants. A programme's processes and technology demonstrate value to real-world impact, scale value to generate revolutionary waves, and secure ongoing and future success with effective programme governance. Similar to the other study, this study also has some limitations. The first limitation of this article is the conceptual nature of the study. In addition, Management 4.0 is an emerging area, so limited studies are available in this area. Further, this study focuses on the role of Management 4.0 and does not propose a framework. This work can be extended in future with framework development, practical tools and case studies.

Declaration of Competing Interest

None.

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