ISBN: 978-93-48091-07-9

11. Economic Growth in the Digital and Industrial Revolution

Dr. Kiran

Assistant Professor, Department of Business Studies,
Panipat Institute of Engineering and Technology.

Abstract:

Industrialization is now industry revolution 4.0 this is the new stage of digitalization in manufacturing sector by using data driven trends by using advance data analytic tool to measure correct result not to nearby but accurate. Human machine interaction with use of advance robotics techniques, machine learning and automation and augmented reality makes it easy to solve complex problems in the field of manufacturing.

21st century is the digital revolution in manufacturing industry and this is 4th industrial revolution using artificial intelligences, machine learning, machine automation makes process of manufacturing easier and advance with managing resources. This new era of advance industrialization giving shaping to new stage of industry but it should be must ensure that workers are well equipped through upskilling and reskilling. This paper give light on different stages of industrial revolution and its impact on industrialization. It further discusses on industry 4.0 application and challenges face by industry in implication of new trends and technology in industry.

Keywords:

Digitalization, Industry Revolution, Robotics, Augmented Reality

11.1 Introduction:

Industrialization is sign of economic development one most indicator considered by economist since first industrial revolution when works were performed by using water, steam power machine at manufacturing process to run machine that time production process was very complicated and time-consuming process that created huge production process. Production process was slow that creates gap between demand and supply [1].

Industry 4.0 is the need of industry for automation in production process so that people can operate machine simply, efficiently and persistently to meet demand and supply. This is the new level of industrialization to control value chain and product life cycle it geared to increasing individually customer requirement.

The major objectives behind industry 4.0 to filling the gap between demand and supply by creating huge production through automation. It affects the areas like value chain management. Production planning and scheduling, time management, research and development and recycle of product [2]

The industry 4.0 has been creating inclusive growth in industry the two milestone on the way to modern production are to be identified as first two revolutions. The third industrial revolution was about automation in production process and services and IT sector. Digitalization, big data, real time networking all value-added system still going on as 4th revolution of industry [3].

It has been profound effects on society and the global economy as a whole, not just on manufacturing [4]. Our living environment is undergoing rapid and continuous change. With the increasing prevalence of the Internet in our daily lives, we are talking about a digital transformation that frequently referred to as the "digital revolution." Things are constantly changing as a result of this digital revolution, particularly in the business sector. It has created a number of opportunities that all businesses, whether or not they are business-oriented, should seize.

Businesses offer new opportunities and risks for the majority of organizations as they distinguish their business models, products, and services. Furthermore, these advancements are constantly changing how consumers interact with companies and with one other although a firm might benefit greatly from adopting digital, the process is difficult since there are numerous barriers to overcome [5]. Digital transformation (DT) is becoming a technology need for meeting the demands and expectations of the world's expanding population, rather than only a technological opportunity.

Today, businesses find it difficult to thrive in the highly competitive marketplace, where the threat of disruption from emerging technologies compromises their efficiency and profitability. A significant turning point for analyzing value propositions, company models, operational processes, and customer interactions is the concept of "digital transformation [6].

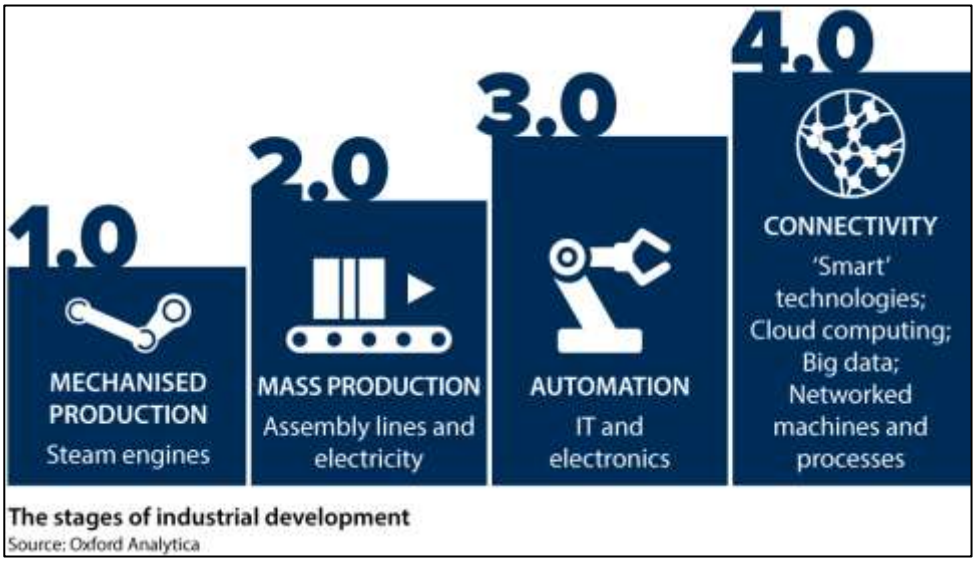

Figure 11.1: Stages of Industrial Development

11.2 Internet of Thing:

Internet of things is a network designing to control up massive digitalization in various area of life [7]. In the manufacturing area IoT put technical solution by cyber physical system (CPS) in manufacturing is called cyber physical production system (CPPS). The main purpose behind using CPM and CPPS to fill the gap between physical and digital domain. Thus, advance infrastructure is not only one solution but smart solution for the problems is necessary. Key components of IoT:

- **Edges Devices:** these devices collect physical data or perform action and receive command to perform physical action.
- **Connectivity and Network:** it creates communication between the device or interaction between human and machine.
- **Data Processing:** large scale data processing, sent to cloud for analysis and storage
- Analytics: To analysis of vast amount of data, it generates model use AI and Machine learning.
- **User Interface:** It allows users to interact with IoT system, monitor device, receive alert and make decision.

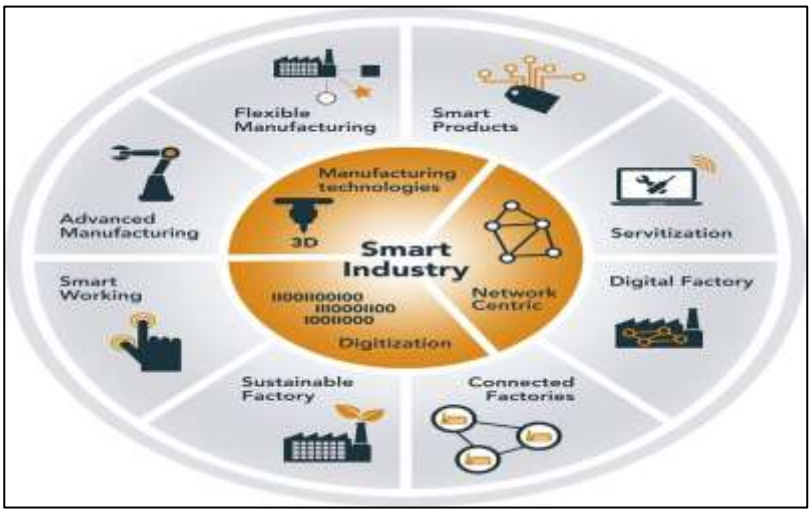

Figure 11.2: Internet of Thing

11.3 Artificial Intelligence and Machine Learning (AIML):

Artificial intelligence and machine learning is transforming the manufacturing industry by improving production quality, increasing operational efficiency and reducing downtime. Artificial intelligence (AI) and machine learning (ML) are central to the autonomous capabilities of Industry 4.0. AI systems can analyse large datasets, identify patterns, and make decisions without human intervention [8]. ML algorithms can be trained to improve performance over time, enabling machines to self-optimize and adapt to changing conditions.

AI is used in applications ranging from quality control and predictive maintenance to supply chain optimization and customer service automation [9]. In essence, AI and ML are the driving forces behind Industry 4.0, enabling the evolution of smart factories, intelligent supply chains, and autonomous operations. By incorporating these technologies, industries can achieve higher levels of efficiency, flexibility, and innovation. AI provides the cognitive capabilities to analyze data, learn from experiences, and make intelligent decisions, while ML continually enhances these systems through self-learning and optimization, contributing to more responsive and resilient manufacturing ecosystems.

As this technological evolution continues, AI and ML will play an even more significant role in shaping the future of manufacturing and other industries, creating a more interconnected, efficient, and intelligent world.

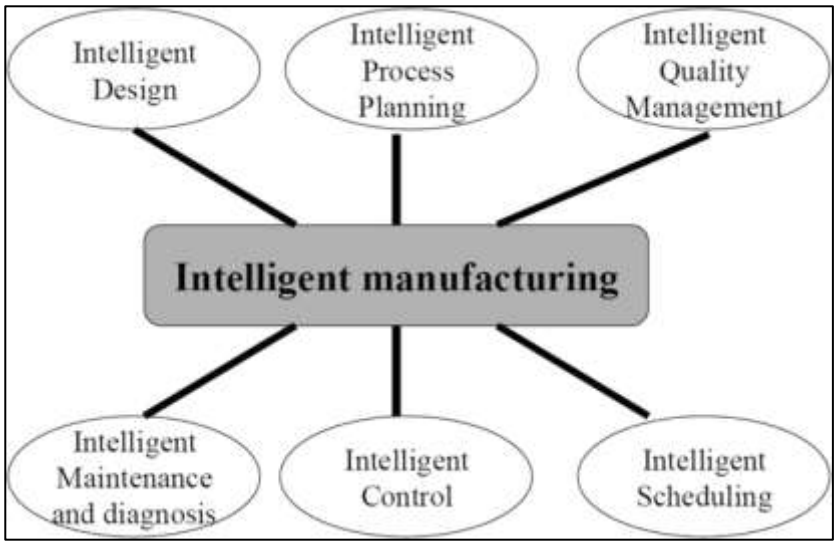

Figure 11.3: Artificial Intelligence and Machine Learning

11.3.1 Impact of AI on Industry 4.0:

Smart manufacturing is most important part of industry 4.0. it can install advance manufacturing system into production process. Smart manufacturing system save production time, improve quality and avoid unnecessary movement of raw material at production floor it can streamline and optimise this operation [10]. In manufacturing, AI brings significant advantages across several key areas, including predictive maintenance, inventory management, production planning, process control, machinery inspection, and logistics. Additionally, it is reshaping industry strategies, allowing manufacturers to focus more precisely on sustainability and adopt customer-centric approaches, often with a greater emphasis on highly customized production. Technologies like 3D printing are enabling companies to shift toward on-demand production, moving away from maintaining large inventories and instead embracing lean manufacturing practices [11]. This allows businesses to respond more efficiently to customer demand while minimizing waste and optimizing resource usage.

11.4 Application of Industry 4.0:

Industry 4.0 is consisting of many areas that influence production process but major applicable area is smart manufacturing, predictive maintenance, supply chain optimization and customization and product personalization. **Robotics** is an engineering field focused on designing, building, and programming robots for a wide range of applications, from manufacturing to healthcare [12]. Recent advancements in both hardware and software have led to the development of a new class of robots known as **soft manipulators**. These robots are capable of handling objects gently without causing damage and can replicate human-like movements with remarkable speed and precision.

Unlike traditional industrial robots, which are typically made from metal, a **soft manipulator** features a mechanical arm constructed from flexible materials such as fabric or rubber. These robots offer several advantages: they are lightweight, cost-effective to produce, and highly adaptable. One of their standout features is their **flexibility**, enabling them to handle delicate objects safely. This makes soft manipulators ideal for applications like **surgical procedures** in medicine and **sensitive assembly tasks**, where precision and care are essential.

Predictive maintenance leverages **machine learning** to anticipate equipment failures before they occur. This allows maintenance teams to schedule repairs and replacements proactively, rather than reacting to unexpected breakdowns, thereby enhancing overall production efficiency. The primary benefit of predictive maintenance lies in its ability to **optimize production capabilities** [13]. By predicting and preventing equipment failures, it maximizes **machine uptime**, ensuring that machines are operational for longer periods and minimizing downtime. This means more time is spent on productive operations rather than dealing with repairs. Additionally, by providing early warnings of potential failures, predictive maintenance helps avoid unplanned production stoppages, ensuring smoother and more continuous operations [14]. Additive manufacturing is a process of creating 3D objects from a digital file by adding material layer by layer. Unlike traditional **subtractive manufacturing**, which involves cutting or shaping a solid block of material, additive manufacturing builds up the part from the ground up. This method provides engineers and designers with **greater design flexibility**, allowing them to create complex and customized parts for a wide range of applications [15].

11.5 Problems and Challenges in Industry 4.0:

Technological innovation and adaptation in industry make simple task of manufacturing. The development of industry has evolved significantly, from the early use of mechanical systems to today's highly automated assembly lines, all driven by the need to be responsive and adaptive to the ever-changing demands of the market. However, challenges persist, including issues related to **integration**, **predictability**, **flexibility**, and **resilience** in the face of unexpected conditions. These challenges often arise during the implementation of new technologies and systems, making it crucial for industries to address these fundamental issues as they move toward more advanced and automated solutions. There are some challenges of implementation of industry 4.0 in the manufacturing sector are given as:

- Manufacturers with legacy IT systems may struggle to integrate their outdated infrastructure with modern software used for analyzing production data. This often necessitates time-consuming retrofitting efforts to make the systems compatible, hindering efficiency and slowing down the adoption of newer technologies [16].
- Many factories operate a mix of modern and decades-old equipment, with the older machines lacking the sensors and internet connectivity needed for a smart factory setup. Retrofitting these machines is often impractical, and manufacturers are reluctant to replace them entirely. Additionally, many manufacturers lack the IT systems necessary to effectively analyze data from their connected machines, further complicating the transition to more advanced, data-driven operations [17].
- In the past, the primary strategy for protecting factory equipment from cyberattacks was to limit its connection to the open internet. However, with the advent of Industry 4.0, the approach has shifted towards greater connectivity—linking machines, systems, and business management processes via the internet. Despite the benefits, many decision-makers in Industrial Internet of Things (IIoT) face growing concerns about the security risks inherent in these new technologies.
  Historical incidents like the Stuxnet malware attack, which targeted manufacturing and power facilities over a decade ago, serve as a stark reminder of the potential dangers. Similarly, the 2017 Petya virus caused significant disruption, halting production at several plants, including those of Beiersdorf, the maker of Nivea skin cream [18].
- Industry 4.0 goes beyond just the shop floor; manufacturers must foster a company-wide understanding of where processes need to evolve and identify which departments must collaborate to execute successful pilots and larger-scale rollouts.
  Achieving this requires adopting new approaches to work, moving away from traditional processes to embrace more integrated and agile methods [19].

11.6 Conclusion and Future Direction:

This paper is focused on 4th generation revolution in industry based on some conceptual data collected from various website and previous research work. Industry 4.0 enables smart, efficient, effective, and highly customized production at an affordable cost.

Advancements in faster computers, more intelligent machines, smaller sensors, and more affordable data storage and transmission are making it possible for machines and products to communicate with one another, share information, and learn from each other.

To better understand the application of Industry 4.0, it is important to explore its nine key pillars. These pillars not only highlight the transformative capabilities of Industry 4.0 but also help identify the challenges and issues that may arise during its implementation. As the adoption of Industry 4.0 grows, new avenues for research and innovation will emerge, addressing the evolving needs and complexities of this technological revolution.

Building on this, the concept of Industry 5.0 has emerged in research as the next stage of industrial evolution. However, Industry 5.0 represents a more comprehensive transformation, encompassing not just economic and manufacturing advancements, but also broader societal impacts. It focuses on the effects on civil society, governance structures, and human identity, extending beyond the purely industrial and economic realms.

11.7 References:

1. Saurabh Vaidyaa,Prashant Ambadb and Santosh Bhoslec (2018). Industry 4.0- A Glimpes, 2nd International Conference on Materials Manufacturing and Design Engineering, Procedia Manufacturing 20, 233–238.
2. Neugebauer R, Hippman S, Leis M, Landherr M (2016). Industrie 4.0- Form the perspective of apllied research, 49th CIRP conference on Manufacturing systems (CIRP-CMS 2016), 2-7.
3. Carreiro P, Industry 4.0: an industrial evolution, rather than a revolution. 2015.[Online]. http://www.techradar.com/news/world-of-tech/industry-4-0-an-industrial-evolution-rather-than-a-revolution-1286048.
4. Sreenivasan, Aswathy & Suresh, Ma. (2023). Digital transformation in start-ups: a bibliometric analysis. Digital Transformation and Society. 2. 10.1108/DTS-12-2022-0072.
5. Sascha Kraus, Susanne Durst, João J. Ferreira, Pedro Veiga, Norbert Kailer, Alexandra Weinmann (2022). Digital transformation in business and management research: An overview of the current status quo, International Journal of Information Management, Volume 63, 102466, ISSN 0268-4012, https://doi.org/10.1016/j.ijinfomgt.2021.102466.
6. Westerman, G., Bonnet, D., & McAfee, A. (2014b). Leading digital: Turning technology into business transformation. USA: Harvard Business Press.
7. daCosta F. Rethinking the Internet of Things, Apress Media, New York: Apress Media; 2013.
8. Rennung F, Luminosu C.T., Draghici A. (2016) Service Provision in the Framework of Industry 4.0, SIM 2015 / 13th International Symposium in Management, Procedia - Social and Behavioural Sciences 221 (2016) 372 – 377.
9. Almada-Lobo F. (2015). The industry 4.0 revolution and the future of Manufacturing Execution Systems (MES), Journal of Innovation Management JIM 3, 4, 16-21.
10. [10] Schumacher A., Erol S., Sihna W. (2016). A maturity model for assessing Industry 4.0 readiness and maturity of manufacturing enterprises, Changeable, Agile, Reconfigurable & Virtual Production, Procedia CIRP 52, 161 – 166.
11. Kagermann H, Wahlster W, Helbig J. (2013). Recommendations for implementing the strategic initiative INDUSTRIE 4.0. Frankfurt am Main: acatech - Deutsche Akademie der Technikwissenschaften e.V;
12. Carreiro P. (2015). Industry 4.0: an industrial evolution, rather than a revolution. (2015) [Online]. http://www.techradar.com/news/world-of-tech/industry-4-0-an-industrial-evolution-rather-than-a-revolution-1286048.
13. Vijayaraghavan V., Rian Leevinson J. (2019). Internet of things applications and use cases in the era of industry 4.0, the internet of things in the industrial sector: security and device connectivity Smart Environments, and Industry, 4.0, pp. 279-298
14. Mourtzis D., Angelopoulos J., Panopoulos N. (2021). Smart manufacturing and tactile Internet based on 5G in industry 4.0: challenges, applications and new trends Electronics, 10 (2021), p. 3175
15. Khan H.I., Javaid M. (2022) Role of internet of things (IoT) in adoption of industry 4.0 J. Ind. Integr. Manag., 7 (2022), pp. 515-533

16. Tucker G. (2021). Sustainable product lifecycle management, industrial big data, and internet of things sensing networks in cyber-physical system-based smart factories J. Self-Govern. Manag. Econ., 9, pp. 9-19
17. Elsisi M., Altius M., Su S.-F., Su C.-L. (2023) Robust kalman filter for position estimation of automated guided vehicles under cyberattacks, IEEE Trans. Instrum. Meas., 72, pp. 1-12
18. Soori M., Arezoo B. (2023). Dimensional, geometrical, thermal and tool deflection errors compensation in 5-Axis CNC milling operations Aust. J. Mech. Eng. pp. 1-15
19. Soori M., Asmael M. (2021) Virtual minimization of residual stress and deflection error in five-Axis milling of turbine blades Strojniski Vestnik/J. Mech. Eng., 67, pp. 235-244