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Industry Revolutions Development from Industry 1.0 to Industry 5.0 in Manufacturing

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Abstract

Industry 5.0 is transformation of the manufacturing sector to a modern manufacturing so that man and machine can perform work hand in hand to achieve more and faster outcomes. This industry revolution improves customer satisfaction by making personalized products. Industry 5.0 with digital technologies creates a new paradigm in manufacturing and supply chain management. Machin learning and artificial intelligent analyze big data in manufacturing to solve complex problems. In the modern business with a rapid technological advancements and globalizations IoT and Industry 5.0 phenomenon are major requirement of competitive advantage and economic growth. Robots used in this revolutions help human to provide higher accuracy in computing and forecasting in industrial automation systems. In the era of technology, mass personalization and smart manufacturing is experiencing a rapid transformation and robots play an important role with the help of human mind. This paper presents the history of Industry revolutions and impact of Industry 4.0 and Industry 5.0 on manufacturing and society. This research also defines some features and capabilities of new Industry revolutions. This paper finally summarizes differences between Industry 4.0 and Industry 5.0.

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1. Introduction

Digital technologies using artificial intelligence systems can solve production challenges. They are used to achieve mass personalization and advanced production with less human effort. In 2015, the concept of Industry 5.0 was introduced and today this revolution has realized its effects on production. Here, advanced production technologies are used to meet customers' personalized demand. Artificial intelligence is used as an emerging tool to improve performance and increase accuracy in the production process. This revolution will shape and transform new business through smart tools. (Xu, Xu, & Li, 2018),(Haleem & Javaid, 2019a)

Despite the technological advances made in past industrial revolutions, the industry continues to grow and develop at an incredible rate. And now Industry 5.0 has attracted the attention of many engineers and managers and they believe that this approach eliminates manpower in the production process. IIoT is at the forefront, with Industry 5.0 providing the conditions for close human-equipment cooperation.(Bryndin, 2020a)

Industry 5.0 allows manufacturers to produce and deliver products and services based on the specific needs and wants of customers. This industrial revolution allows industries to design appropriate production processes using artificial intelligence to be able to personalize products and services for customers. This revolution actually improves manufacturing and automation processes. The vision of the modern manufacturing industry is to create a specialized and better job. (Lu, 2017a),(Özdemir & Hekim, 2018),(Reinhardt, Oliveira, & Ring, 2020)

One of the applications of virtual technology tools such as virtual and augmented reality is labor training. This revolution will increase efficiency and productivity. In the Industry 5.0, devices, tools and equipment, and a set of programmable intelligent sensors play an important role. Industry 5.0 also increases added value in production and manufacturing by providing creative and innovative solutions. (Da Xu, Wang, Bi, & Yu, 2013),(Sachsenmeier, 2016),(Doyle-Kent & Kopacek, 2019),(Yli-Ojanperä, Sierla, Papakonstantinou, & Vyatkin, 2019)

The technological mind (Bryndin, 2020b) and the use of intelligent tools (Bryndin, 2014), and automated and digital systems with the help of artificial intelligence can lead the world to the formation and management of industry 5.0. (Bryndin, 2017)

Robots with human brains in Industry 5.0 increase the speed and progress of multiple activities simultaneously. Therefore, an industrial robot is one of the main pillars of Industry 5.0 and will be used to manufacture personal

products on a large scale. This creates a new and fully automatic production method. Of course, these results are achieved with the close cooperation of humans and machines and meet the needs of customers. Intelligent software creates human-machine interaction in a shared space. The main purpose of this interaction is to increase production capacity and improve quality and accuracy in the industry.(Z. Li & Da Xu, 2003),(Da Xu, 2014),(Ozkeser, 2018) As a result, the speed of responding to market changes increases and leads to flexibility in production.

The use of robots in Industry 5.0 does not mean the departure of humans from the production cycle, but increases the role of mechanical components and the role of humans in production. In this cooperation and interaction, repetitive and uniform activities to robots and innovative activities and creatively delegated to humans. This division of labor increases human regulatory responsibility in production and manufacturing, and thus improves the quality of products and services.(Bryndin, 2020a)

Industry 5.0 begins to take shape with add-on technologies based on Industry 4.0 and the use of the 5G network. Industry 5.0 makes production and manufacturing processes more fully intelligent and on the other hand enhances process flexibility, and in this regard, 5G network has a decisive role.(Bryndin) Industry 5.0 plays an important role in meeting the personal needs of the customer. Different and unique features of this revolution increase customer satisfaction and enthusiasm. One of the effective tools in this revolution is information technology, which increases the efficiency of machines and thus achieves optimal time and cost to do Activities. Information technology improves design, manufacturing process and execution operations, which leads to continuous improvement.(Da Xu, He, & Li, 2014),(Xu et al., 2018),(Haleem & Javaid, 2019b)

2. Industry Revolution Development

For many years and centuries, the production of goods and services such as food, clothing and weapons were done by humans and manually, but with the beginning of the eighteenth century, these processes changed with the introduction of the Industrial Revolution 1.0 and this period became a turning point in the industry and development and growth accelerated, which in this section is a review of this evolution.

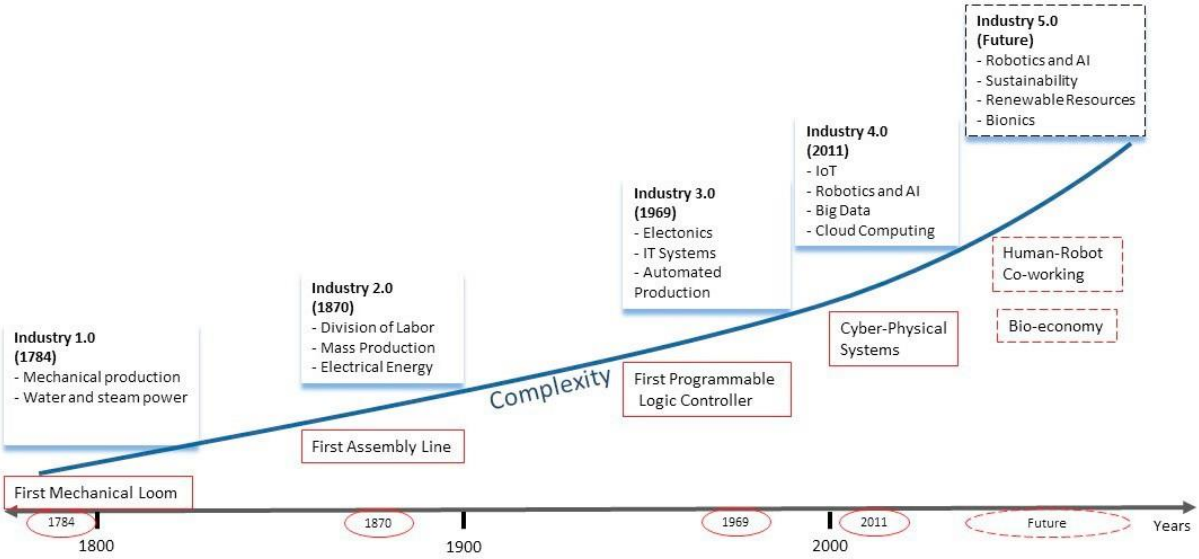

Fig.1.Industry Revolution Development (Demir, Döven, & Sezen, 2019)

2.1 First Industrial Revolution (IR1.0): Mechanical production

Steam and mechanization in the early eighteenth century led to the beginning of Industry 1.0. During this period, mechanization led to an eightfold increase in production in the spinning industry. Steam as the main feature of this revolution in large industries led to the development and improvement of productivity. In this revolution, steam power replaced human muscular force in the spinning industry. Following the use of steam power, improvements were made in steam ships and steam locomotives and caused another great change in this period because this technology reduced time for people and goods to travel long distances.(GEORGE & GEORGE)

2.2 Second Industrial Revolution (IR2.0): Mass production

Beginning in the nineteenth century, the phenomenon of electricity was introduced as the main source of power. One of the advantages of electricity compared to steam and water was its ease of use. This feature made this power supply usable in special machines and different. In addition to the advent of electricity, management tools also made significant progress in this period and improved the performance and efficiency of industries. Division of labor is a prominent feature of this period that increased profits. In this period, mass production and Assembly lines were created and people like Frederick Taylor studied the jobs and productivity of workers, and as a result, the concepts and principles of agile and pure

production were introduced, and increasing the quality and quantity of production was included in the producers' program. (GEORGE & GEORGE)

2.3 Third Industrial Revolution (IR3.0): Automated production

In fact, Industry 3.0 was created by the advent of electronics and computer technology in the middle of the twentieth century. During this period, manufacturing automation systems were developed in factories. These technologies reduce the challenge of employees in various tasks and the concept of mass production. (GEORGE & GEORGE)

2.4 Fourth Industrial Revolutions (IR4.0): Digital Transformation

The use of information and communication technology in industries is a distinctive feature of Industry 4.0 compared to previous revolutions. Production systems in Industry 3.0 were equipped with computer technology. In Industry 4.0 the connection of these computer systems through the network was expanded and the Internet platform created a wide connection between physical and cyber systems, and as a result, intelligent factories were created. In intelligent factories, production systems, components and people are connected through the network. (GEORGE & GEORGE)

The theme of Industry 4.0 is "smart manufacturing for the future", which was a German initiative. This revolution, similar to previous revolutions, has emerged with the aim of increasing productivity and achieving mass production using innovative technologies. During this period, a large number of emerging technologies contributed to the emergence of the Industry 4.0, the most important of which are the internet, the internet of things, robotics and artificial intelligence, big data and cloud computing, virtual and augmented reality, smart factories, smart logistics and environmental intelligence.(Demir et al., 2019)

2.5 Fifth Industrial Revolutions (IR5.0):

In the previous revolution, Industry 4.0, equipping manufacturing plants with intelligent facilities and the Internet of Things using cognitive computing and connecting cloud servers to each other was considered, while industry 5.0 emphasizes the return of human hands and minds in the industrial context. The human and machine eras are looking for ways to work together to increase the effectiveness and proper use of resources. (GEORGE & GEORGE)

For industry 5.0, there are two approaches and perspectives. The first is the cooperation of robots and humans. In this perspective, humans and robots have close communication and cooperation at the required times

and places. In this cooperation and interaction, human beings It focuses on activities that require creativity and has a supervisory role, and other tasks are the responsibility of robots. Another approach of industry 5.0 is bio economics, which deals with the correct and smooth use of biological resources. The approach strikes a balance between the elements of the environment, industry and economics, and sustainability is considered.(Demir et al., 2019)

3. Industry 4.0

3.1 Main Characteristics of Industry 4.0

Industry 4.0 is growing and developing in the fourth industrial revolution, and in fact, the digital transformation with the effect of creating added value for products and services is one of its prominent features.(Blunck & Werthmann, 2017)

This revolution was introduced in 2011 by the German government to increase competitiveness and by the ICT strategy.(Skobelev & Borovik, 2017) The Fourth Industrial Revolution improved productivity and the development of business models and the emergence of new commercial services and products.(Tupa, Simota, & Steiner, 2017)

One of the conditions of these integrations is widespread access to sensor networks (for example, radio frequency identification - RFID), in which the smart objects created enable real-time communication between all stakeholders in the production system. This technology-driven development serves as the basis for the use of new business models in smart factories.(Niesen, Houy, Fettke, & Loos, 2016)

In a smart factory, there is a close relationship between machine and machine (M2M) and machine and human (M2H). CPS is one of the basic tools in the Industry 4.0. For communication and coordination through IoT, systems and special equipment is required. In this situation, personalization of goods and services is provided for the customer by communicating the physical and digital world.(Peraković, Periša, Cvitić, & Zorić)

3.2 Main technologies of Industry 4.0

Although advanced technologies are part of the Industry 4.0, it is important to note that the Industry 4.0 does not focus on one or more specific technologies, but in fact the main goal of the Industry 4.0 is to produce intelligent products and processes. These processes, which use advanced technologies, are shown in Figure 2.(Peraković et al.). Digitization and integration of data in the value chain is created by converting and integrating all activities in different sectors in a smart factory.(Peraković et al.)

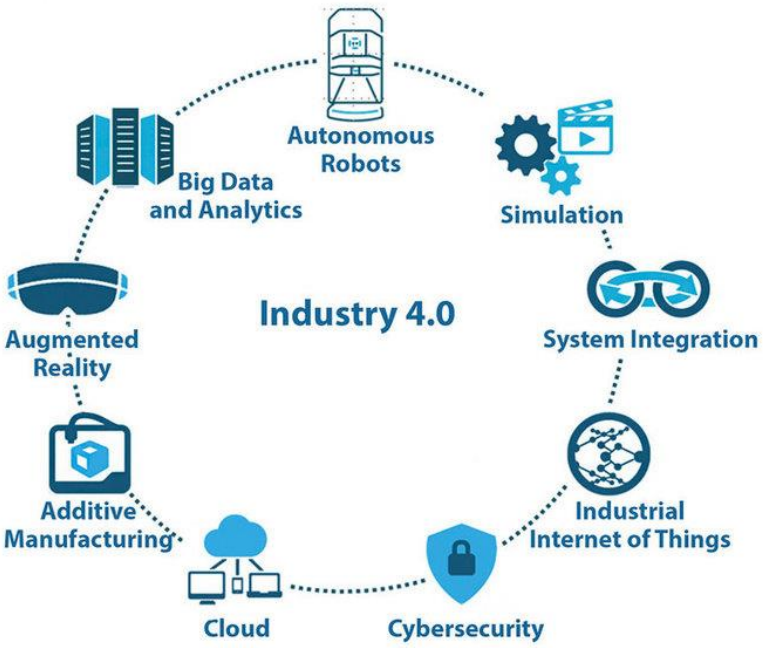

Fig.2. Main technologies of Industry 4.0 (Peraković et al.)

3.3 Key objective of Industry 4.0

Given the global trend and the vast and evolving context of innovation, technology development is essential to achieve the goals and requirements of Industry 4.0. Despite the development of technology, production automation is also needed to accelerate operational processes. Despite the data-driven industrial revolution, a new pattern is emerging based on the clever combination of different technologies.

Proper classification and utilization of the technologies presented in Table 1 will create more benefits in Industry 4.0 using the digital revolution. (Dalenogare, Benitez, Ayala, & Frank, 2018),(Weyer, Schmitt, Ohmer, & Gorecky, 2015),(Qin, Liu, & Grosvenor, 2016),(Wan et al., 2016),(Gorecky, Schmitt, Loskyll, & Zühlke, 2014) With the integration and integration of these technologies, the process of digitalization of industries happens faster and makes the goals of industry 4.0 meet faster. Achieving these goals in different industries and businesses is not only a fantasy and a game, but also a purposeful mission. Industry 4.0 is in a special approach to various challenges in the political, social, scientific, economic and technological fields.(Lasi, Fettke, Kemper, Feld, & Hoffmann, 2014),(S. P. Singh, Nayyar, Kumar, & Sharma, 2019),(P. Singh, Gupta, Jyoti, & Nayyar, 2019),(Das & Nayyar, 2019),(Jazdi, 2014),(Lunn, 1995)

Table1. Key objectives of Industry 4.0

Technologies	Description
IIOT	The Internet of Things (IIoT) is one of the concepts in the virtual world. Lasers, global positioning systems and sensors are elements of connecting the virtual world to the real world.(Zhou, Liu, & Zhou, 2015)
Cyber physical system	Cyber physical systems are related to the real world.(Lu, 2017b) CPS and other digital technologies help to integrate the real world with the virtual world. These technologies create intelligent factories that accelerate energy production, logistics, transportation, and so on.(Lee, Kao, & Yang, 2014),(Zhou et al., 2015),(Lasi et al., 2014),(S. P. Singh et al., 2019)
Cloud computing	This technology is used as a computing solution to provide services on the Internet at an optimal cost. In fact, with this tool, users can share resources with the help of a dynamic memory and use software, hardware and other infrastructure to calculate data if needed.(Lee et al., 2014),(Lu, 2017b),(Zhou et al., 2015)
Agility and sequencing	The current method is a mechanism that enables the system to make adjustments and send parts based on the appropriate sequence in the production system based on the customer's opinion and wishes. This method is based on the time and needs of the customer.(Lee et al., 2014),(Lu, 2017b),(Zhou et al., 2015)
Additive manufacturing	The application of this technology is in the manufacture of parts with the help of 3D printing. The mentioned technology improves the production and manufacture of products based on the customer's order and wishes and strengthens personalization in the Industry 4.0.(Lee et al., 2014),(Lu, 2017b),(Zhou et al., 2015)
Big data, data mining and data analytics	This concept is actually used to exploit and use large volumes of heterogeneous data on the Internet. This technology, along with data mining and data analysis techniques, improves data analysis and their use in production processes and leads to process optimization and cost reduction.(Lee et al., 2014),(Lu, 2017b),(Zhou et al., 2015)
Artificial intelligence	Artificial intelligence is a science that uses adaptive and collective intelligence to extract useful information when needed. Applied tools in this technology are machine learning and innovative algorithms.(Lee et al., 2014),(Lu, 2017b),(Zhou et al., 2015)
Cobot	A new generation of robots that has close cooperation with humans without security restrictions. These types of robots can be programmed to facilitate use in production.(Lee et al., 2014),(Lu, 2017b),(Zhou et al., 2015)
Augmented reality	Augmented reality is used in cases such as the selection of warehouse parts and maintenance instructions for mobile devices and equipment. Augmented reality helps people to have the information needed to make the right decision at the right time.(Lee et al., 2014),(Lu, 2017b),(Zhou et al., 2015)
CAD/CAM	These programs are used to design and produce products using computer software.(Lee et al., 2014),(Lu, 2017b),(Zhou et al., 2015)
MES/SCADA	Manufacturing Execution Systems (MES) are computer systems used in manufacturing to track and document the conversion of raw materials into finished goods.(Lee et al., 2014),(Lu, 2017b),(Zhou et al., 2015)
Sensoring	This tool is used to improve the capabilities of robots and production processes such as measurement, reasoning and decision making. (Lee et al., 2014),(Lu, 2017b),(Zhou et al., 2015)
On demand manufacturing	To stay in the world of competition, providing customer needs and wants is the first priority of product manufacturers and service providers, so organizations must achieve customer satisfaction based on dynamic patterns and considering the agility in responding and setting priorities. (Lee et al., 2014),(Lu, 2017b),(Zhou et al., 2015)

3.4 Main benefits of Industry 4.0

At present, customers are looking for the best products and services. From the customers' point of view, low cost, high quality and availability of products and services are of special importance, so companies are always looking for continuous improvement and optimization of processes for meet customer expectations. Table 1

describes the benefits of Industry 4.0 in business.(Almada-Lobo, 2017)

Table2. Main benefits of Industry 4.0 (Paschek, Mocan, & Draghici, 2019)

Benefits	Description
Efficiency	By using the automation system and using other elements of Industry 4.0, productivity increases. In Industry 4.0, using different tools, the need for people decreases, and on the other hand, the quality of products increases and losses are reduced.
Agility	In Industry 4.0, due to high standardization and production in lower circulations, flexibility increases and as a result, the agility of the organization in responding to customer needs improves.
Innovation	Due to the fact that industry 4.0 has a great variety and low volume of products, so it is a good space for innovation and introduction and testing of a new product.
Customer experience	Speed in responding to customer needs and having the right information about the needs of users makes manufacturers and service providers to introduce the right product to the market at the right time.
Costs reduction	In Industry 4.0, despite the initial investment made for transformation, costs continue to fall as quality discrepancies are reduced and less material is wasted, and staff and operations costs are reduced.
Revenues	By providing better quality products and services and lower costs, it increases the satisfaction of current customers and, as a result, facilitates entry into larger markets and more customers.

In Industry 4.0, despite the integration of cyber and physical systems, a proper organizational structure is needed to make the best use of the benefits of this revolution. Therefore, strategic planning, participatory management and dissemination of technology standards in the organization are the basic principles of industry.(Ustundag & Cevikcan, 2017). In most scientific research on the Industrial Revolution 4.0, the technical areas have been studied more and less, and issues such as management and organizational issues that are important points have been less considered.(Mohelska & Sokolova, 2018) On the other hand, due to technological advances in this revolution, there is not enough knowledge and skills to implement and benefit from these tools. Another complication of this period is the fear of job security of employees, which with the emergence of the phenomenon Automation and the use of robots in production processes is a matter of concern. Issues related to the use of the Internet and the Internet of Things and security issues and the reliability of this platform are other concerns of the Industry 4.0.(Lewis, 2017)

4. Industry 5.0

4.1 Main characteristics of Industry 5.0

In Industry 4.0, the issue of mass production customization was mentioned, which does not achieve full customer satisfaction in the new era, but mass production and personalization of production can increase this satisfaction, and this goal will be achieved if humans return to production processes.(Østergaard, 2018) Therefore, the need to create an

industry environment of 5.0 is felt more than ever. In industry 5.0, human-machine cooperation and participation in smart factories increases production capabilities and improves product personalization.(Johansson, 2017)

The development of innovation and creativity in Industry 5.0 is improved due to the use of smart tools. In business in this period, devices, equipment and smart materials lead to intelligent production. In Industry 5.0 due to high flexibility in construction, efficiency, Quality and efficiency increase and thus improve customer satisfaction. Sensors and tools used in this revolution increase the computing power of the system and help meet customer needs. By integrating modern software and technologies In Industry 5.0, decision-making is facilitated in complex processes.(Chen, 2017),(Demir et al., 2019) Table 3 discusses the four main elements of Industry 5.0.

Table3. Main characteristics of Industry 5.0

No.	Elements	Description	References
1	Intelligent materials	• Smart materials have changeable properties that change with temperature, humidity, light, etc. • These materials are used in various industries such as textiles, medicine and electronics and aerospace industries • In the 5.0 industry, smart material capabilities play an important role	(X. Li, Shang, & Wang, 2017),(Hakanen & Rajala, 2018),(Yang et al., 2019),(Haleem & Javaid, 2019a)
2	Intelligent devices	• Computing capabilities are a prominent feature of smart devices in the Industry 5.0. • Ability to connect in smart devices for effective management and monitoring. • Internet-connected cameras in smart devices improve the operation control system.	(Crutzen, 2005),(Derby et al., 2007),(Matindoust, Baghaei-Nejad, Abadi, Zou, & Zheng, 2016),(Shammar & Zahary, 2019)
3	Intelligent automation	• This element integrates different aspects of humans, software and machinery and improves their participation. • Automation system is effective for detecting process errors. • Machine learning in this system increases productivity in complex tasks and processes and is useful in reducing process time.	(Mekid, Schlegel, Aspragathos, & Teti, 2007),(Butner & Ho, 2019),(Pagliosa, Tortorella, & Ferreira, 2019)
4	Intelligent systems	• Intelligent systems can be used in various parts of the supply chain, such as transportation, logistics, research and development, etc. • In industry 5.0, this system increases the ability to interact and react to environmental changes • Intelligent systems allow the customer's personalized needs to be met at the required time	(Dragcevic et al., 2007),(Sykora, 2016),(Xie, Liu, Fu, & Liang, 2019),(Sakamoto, Barolli, Barolli, & Okamoto, 2019)

In industry 5.0, due to the use of smart materials, the properties of manufactured products can be changed based on conditions and needs. Software programs are the basis of digital manufacturing and gaining experience in this field and play an important role in the production and manufacturing of complex products. In this revolution, building smart and innovative products reduces inventory and physical storage.(Haleem & Javaid, 2019a)

4.2 Critical components of Industry 5.0

The fifth industrial revolution with the help of intelligent machines increases safety, improves quality and also reduces waste, and on the other hand develops creativity and innovation in production. In this revolution, humans have a lesser role and artificial intelligence plays an important role. The advantage of robots in the system is that the flow of materials and information is easy and environmental conditions have less impact on processes.(Lu & Da Xu, 2018),(Özdemir & Hekim, 2018),(Haleem & Javaid, 2019a) Table 4 describes the important components of Industry 5.0.

Table4. Critical components of Industry 5.0

No.	Components	Description	References
1	Internet of Things(IoT)	• Connecting devices and machines to the Internet changes the way the production system and supply chain change • Tools and equipment are always monitored using control and monitoring tools • With the Internet of Things, the experience of customers and manufacturers is rapidly increasing	(Makori, 2017),(Pinochet, Lopes, Srulzon, & Onusic, 2018),(Chatterjee & Kar, 2018),(L. Li, 2018),(Shammar & Zahary, 2019),(Leminen, Rajahonka, Westerlund, & Wendelin, 2018),(Aziez, Benharzallah, & Bennoui, 2019),(Zhang & Chen, 2020)
2	Big Data	• The stored data and information improves production-related activities. • This component is used in various manufacturing industries and financial and managerial fields • Data and their analysis help to increase productivity and improve quality in the production process and facilitate optimal decision making	(Pauleen & Wang, 2017),(Ahmed & Ameen, 2017),(Wiencierz & Röttger, 2017),(Tan, 2018),(Santoro, Fiano, Bertoldi, & Ciampi, 2019),(Khan, 2019),(Xu & Duan, 2019)
3	Robots	• Robots increase production volume and improve product quality, and on the other hand, increase profitability by reducing costs and losses and preventing errors. • Increases the efficiency of production processes and equipment • Producing of products and providing services to the customer according to their needs and wants	(Ranky, 2003),(Müller, Vette, & Scholer, 2014),(Tang, Asif, & Webb, 2015),(Bloss, 2016),(Malik & Bilberg, 2019),(Vergara, Borghesan, Aertbeliën, & De Schutter, 2018)
4	Artificial Intelligent (AI)	• Human-like intelligence improves the performance of production process activities • Artificial intelligence is a useful tool in medicine for diagnosis, treatment of disease and remote surgery	(Jovic, Golubovic, & Stojanovic, 2017),(Liu et al., 2018),(Paschen, Kietzmann, & Kietzmann,

		• With this tool, complex macro problems and issues can be solved in less time and at a lower cost	2019),(Lauterbach, 2019),(Narain, Swami, Srivastava, & Swami, 2019),(Lu, 2019a)
5	Smart Manufacturing	• The Internet connects machines and equipment and provides intelligent manufacturing with the automation system created • In intelligent production, equipment and machinery failures are identified to be remedied • Ordering raw materials to improve the distribution network plays an important role in intelligent production	(Al-Sayed & Yang, 2018),(Daudt & Willcox, 2018),(Torres, Pimentel, & Duarte, 2019),(Ghobakhloo & Fathi, 2019)
6	Smart Material	• Smart materials have changeable properties that can change to suit the situation, which plays an important role in the Industry 5.0 • By changing the temperature and pressure, the shape of the product can be changed and controlled • Control and deformation of products using smart materials based on the needs and desires of the manufacturer	(Bogue, 2012),(Chiodo & Jones, 2012),(Bogue, 2014)
7	3D Printing	• Using this feature, a physical 3D model is created based on computer models • This method is used to produce a test sample exactly according to the original product • By using easy fabrication of the test sample and modifying it if necessary, the efficiency of making the original product is increased	(Kanada, 2016),(Bai, Liu, Wang, & Wen, 2017),(H.-C. Wu & Chen, 2018),(Yuan, Zhu, Xu, & Chen, 2018),(Javaid & Haleem, 2018),(Ali, Batai, & Sarbassov, 2019)
8	4D Printing	• With this technology, product manufacturing is done with smart materials • By adding the fourth dimension to 3D, time, 4D technology is created • In this technology, environmental changes can change the shape of the product	(Pei, 2014),(Pei et al., 2017),(Javaid & Haleem, 2019)
9	5D Printing	• In 5D technologies, the product is made in the X, Y, Z axes, and on the other hand, the bed and head of the printer are movable. • 5D printing allows the product to be manufactured in several directions by reducing pressure and load • One of the applications of this technology is to make car parts that must have high reliability and strength	(Gillaspie et al., 2016),(Zeijderveld, 2018),(Haleem & Javaid, 2019a)
10	Virtual Reality	• One of the advantages of this technology in manufacturing is learning knowledge and establishing knowledge management and improving skills in production and automation systems. • It clearly shows the problems of the production system • Improves access to information and better decision making, thus helping the product development process	(Xia, Lopes, & Restivo, 2013),(Jung & tom Dieck, 2017),(Baxter & Hainey, 2019)

Troubleshooting and increasing system utilization becomes easier in the fifth revolution with the help of advanced technologies. Big Data is also one of the useful system analysis tools that are considered in this revolution. In Industry 5.0, software improve process of research and development.(Lu, 2019b),(Aceto, Persico, & Pescapé,

2020) Virtual reality is also widely used to provide three-dimensional information that creates real reality. Machines are also programmed and performed activities with the help of other advanced technology tools such as humans. In this case, machines have this capability. To solve the mistakes made by themselves and to be able to solve complex problems. These components are among the obvious and basic tools of the fifth industrial revolution that achieve the goals of various industries.

4.3 Capabilities of industry 5.0

One of the main goals of Industry 5.0 is to meet the needs and wants of the customer with mass customization of products and services. In this process, facilities for automatic tracking of products are considered and it makes the supply chain smarter and the customer is informed. In the production of current products, information is analyzed and updated with advanced technologies, and on the other hand, this information is used to produce new products.(Lu & Da Xu, 2018),(Nahavandi, 2019) Capabilities of Industry 5.0 are classified into four major areas. Table 5 discusses the capabilities of industry 5.0.

Table5. Capabilities of Industry 5.0

No.	Capabilities	Description	References
1	Digital decision making	• Using digital data and automation system, the desired decision is provided in complex situations. • Increases efficiency and productivity and improves product results with innovative decisions • Improves teamwork, creativity and effective communication between people	(Becker, Faria, & Duretec, 2014),(Yan et al., 2017),(Gürdür, El-Khoury, Seceleanu, & Lednicki, 2016),(Chatterjee & Kar, 2018),(Swan, Dahl, & Peltier, 2019),(Covaci & Zaraté, 2019)
2	Digital service	• Help develop a competitive strategy using digital information • To measure the performance and progress of people and empower them • For feasibility and deployment of new digital systems to improve the supply chain	(Uutoni, 2018),(Bolton et al., 2018),(Vannucci & Pantano, 2019),(Wanyan & Hu, 2019),(S. Li, Hao, Ding, & Xu, 2019)
3	Intelligent business	• Integrated data in new technology makes a significant difference in business • Employee, customer and stakeholder satisfaction is improved by using IT management systems • With the establishment of knowledge management in the areas of sales and process optimization, business growth is created	(D. D. Wu, Kapoor, & Sherif, 2012),(Aruldoss, Travis, & Venkatesan, 2014),(Ghouchani, Jodaki, Joudaki, Balali, & Rajabion, 2019),(Cao, You, Shi, & Hu, 2020)
4	AI-based sales and marketing	• Speed in data analysis in sales and marketing using artificial intelligence improves customer satisfaction • Artificial intelligence provides appropriate solutions and approaches to the sales department based on data analysis • Identify weak vendors and help improve them by analyzing data from top vendors	(Paschen et al., 2019),(Upadhyay & Khandelwal, 2019),(Weber & Schütte, 2019),(Narain et al., 2019)

Ideas and creativity in the fifth revolution with the help of various

technologies improve products and services and expand in the field of production. Robots along with humans with the help of digital technology communicate with each other and help make decisions for overcoming obstacles and complex problems.(Javaid & Haleem, 2020)

5. The main differences between Industry 4.0 and Industry 5.0

The exchange of knowledge and information in society 4.0 was not enough and desirable, so the cooperation between humans and machines was difficult. In this society, due to the decrease in human ability over time and increasing age, executive activities needed more effort and Humans had to work more time, but in a society 5.0, due to the human-machine collaboration, there is a good connection between real and virtual space.(Potočan, Mulej, & Nedelko, 2020)

In society 4.0, factory data was collected by various tools and sensors and stored in the cloud for analysis. To access this information in databases, people use the Internet in cyberspace. There is a lot of information in the factory environment that is received and stored by different sensors, so this large amount of information must also be stored in cyberspace environment to be analyzed by artificial intelligence. Data must be made available to individuals for use that creates added value in products and services.

According to the different needs of users and customers, data analysis by artificial intelligence and value creation, allows the custom production of goods based on the needs of each customer.

The following can be achieved:

- Flexibility and stability in production planning and optimal inventory management against the current demands of the customer,
- Save more on production and reduce costs and make better use of labor,
- Appropriate and timely distribution of products or services,
- Speed in delivering products to customers and reduce shipping delays.

If the above mentioned solutions are exploited, customer satisfaction will increase and industrial competition will be strengthened, and it will even reduce costs and improve environmental conditions. (Peraković et al.)

Table6. A Comparison of Industry 4.0 and Industry 5.0 Visions (Demir et al., 2019)

No.		Industry 4.0	Industry 5.0 (Vision 1)	Industry 5.0 (Vision 2)
1	Motto	Smart Factories	Human-Robot collaboration	Bio economy
2	Motivation	Mass Production	Smart Society	Sustainability
3	Power Source	Electricity fuels Renewable energies	Electricity Renewable energies	Electricity Renewable energies
4	Technologies	Internet of Things (loT) Cloud Computing Big Data Robotics Artificial Intelligence (AI)	Human-Robot Collaboration	Sustainable Agricultural Production Bionics
5	Research field	Organizational Theory Process Improvement and Innovation Business Administration	Smart Environments Organizational Theory Process Improvement and Innovation Business Administration	Agriculture Biology Waste Reduction Process Improvement and Innovation Business Administration

In Industry 4.0, the focus was on customization with the help of intelligent manufacturing, and production was done using tools such as the Internet of Things, artificial intelligence, physical cyber systems, the cloud, and cognitive computing. (Lu & Da Xu, 2018) Devices and machines are created through the circulation of information. (Rajput & Singh, 2019),(Chen, 2017),(L. Li, 2018)

One of the salient features of Industry 5.0 is the human connection with production, which is provided through more human intervention and participation in the production system. In this revolution, the speed and accuracy of the automation system are increased by using critical thinking skills. Table 7 describes the differences between the two revolutions 4.0 and 5.0. (Javaid & Haleem, 2020)

Table7. Major Difference between Industry 4.0 and Industry 5.0 (Javaid & Haleem, 2020)

No.		Industry 4.0	Industry 5.0
1	Focus	Mass customization of the product	Mass personalization of the product
2	Use of Data	Digital	Intelligent
3	Experience	unique	innovative
4	Coordination/collaboration	coordination between machines and information technology	collaboration of human with machines
5	Factories	digital	smart
6	Tasks	Customized in lesser time and costs	precise and creative in lesser time and costs
7	Technologies	application of information technologies (digitization)	application of advanced technologies (Globalization)

In Industry 5.0, to upgrade and improve the production system, devices and equipment are automatically upgraded. In this revolution, with the help of intelligent systems, tools are selected correctly and overproduction is prevented.(L. Xu, 2000),(L. D. Xu, 2000),(Gürdür et al., 2016) The intelligent system in industry 5.0 requires optimal digital communication in which data and information play an important role. Data in this system is intelligently analyzed and improves research and development facilities. On the other hand, the intelligent and automated internal systems of the factories are connected to the systems of other factories and create an intelligent set of factories and improve the production support and provide the desired services to the customer.(Kim, 2017),(Demir et al., 2019),(Gorodetsky, Larukchin, & Skobelev, 2019) This system makes the supply chain more intelligent and increases its competitiveness and efficiency.(Peruzzini & Stjepandić, 2018)

Conclusion and Discussion

Technological innovation and revolution change the world quickly and it causes change in customer satisfaction level and creates new market. With the development in the field of Internet and IoT, Industry 4.0 was evolved from 2000 to date. Industry 4.0 is characterized by IoT, Big data, 3D printing and Artificial Intelligent. Industry 5.0 phenomena is also taking place from 2016.Charactristics of Industry 5.0 are Smart manufacturing, IoT, Robots, Artificial Intelligent, smart material and 5D printing. In the upcoming revolution known as Industry 5.0, virtual world cooperates closely to real world with the help of intelligent agents and automated systems with artificial intelligence. Transformation from Industry 4.0 to Industry 5.0 causes changes from the mass customized production to the personalized production. Human-Robot co-working will be big change in manufacturing in Industry 5.0. The advancement of this revolution is to prevent error in systems and speed up the manufacturing process by the digital devices with the human

intelligence.

One of the tools that may lead to the Sixth Industrial Revolution (Industry 6.0) is quantum superiority. Physics has many applications in business analysis. Business analysts, financial risk managers, and project managers all make decisions through physics-based visualizations, which are largely uncertain. With the help of quantum computers and advanced physics, the accuracy of such predictions can be increased. Even a slight increase in accuracy can be very appealing to business executives and encourage them to spend more.

In addition to physics, data science and machine learning are technologies that are expected to benefit greatly from the processing power of quantum computing.

Quantum computers will be very effective in solving problems related to process optimization and machine designs. Their ability to work through massive combinations within models to discover new materials with specific properties also greatly enhances science and chemistry.

AI lends itself to quantum computing. Imagine any kind of problem in which patterns need to be quickly identified from a large data set. This is the basis of the current trend towards artificial intelligence technologies, and this power potentially greatly expands the use of quantum computing. Problems that are difficult to solve today, such as real-time decision making by autonomous vehicles or sophisticated modelling for the treatment of diseases or the discovery of new materials, are a set of problems that are highly optimized to be solved using quantum computing.

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