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RESEARCH ARTICLE

INDUSTRY 4.0 AND ITS IMPORTANCE IN CIVIL AVIATION

Endüstri 4.0 ve Sivil Havacılıktaki Önemi

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ABSTRACT

The world defines the fourth industrial revolution as higher automation, digitalization and data exchange in production technologies. Industry 4.0 will bring innovations to many fields and industries, as did the previous industrial revolutions, and the aviation industry, which is one of the first implementers of this concept, will also get its share of these innovations. The fact that the concept of time is very important, especially in the aviation industry, and the maximum application of safety and security measures, reveals the importance of Industry 4.0 once again.

In this study, the concept of Industry 4.0 has been examined, the development and components of Industry 4.0, the relationship between aviation and industry 4.0, the concept of aviation 4.0 to increase safety levels in aviation, the concept of aviation 4.0 in aircraft production and the four effects of industry 4.0 on the aviation industry. In this direction, it is aimed to evaluate the innovations brought by Industry 4.0 to the aviation industry in the context of the technologies used.

Key words: Industry 4.0, Civil Aviation, Aviation Management.

ÖZET

Dünya, içinde bulunduğumuz çağda dördüncü sanayi devrimini üretim teknolojilerinde daha yüksek otomasyon, dijitalleşme ve veri alışverişi şeklinde tanımlamaktadır. Endüstri 4.0, kendinden önceki sanayi devrimlerinin yaptığı gibi pek çok alana ve endüstriye yenilik getirecek, bu kavramın ilk uygulayıcılarından biri olan havacılık sektörü de bu yeniliklerden payını alacaktır. Özellikle havacılık sektöründe zaman kavramının çok önemli olması, emniyet ve güvenlik önlemlerinin maksimum düzeyde uygulanması, Endüstri 4.0'ın önemini bir kez daha ortaya çıkarmaktadır.

Bu çalışmada Endüstri 4.0 kavramı irdelenmiş, Endüstri 4.0'ın gelişimi ve bileşenleri, havacılık ve endüstri 4.0 ilişkisi, havacılıkta güvenlik seviyelerini artırmak için havacılık 4.0 kavramı, uçak üretiminde havacılık 4.0 kavramı ve endüstri 4.0'ın havacılık endüstrisi üzerindeki dört etkisi konularına değinilmiştir. Bu doğrultuda Endüstri 4.0'ın havacılık endüstrisine getirdiği yeniliklerin kullanılan teknolojiler bağlamında genel olarak değerlendirilmesi amaçlanmıştır.

Anahtar Kelimeler: Endüstri 4.0, Sivil Havacılık, Havacılık Yönetimi

1. INTRODUCTION

The aviation sector has a very important share for the world economy and this share will increase with the rapid progress of technology. Due to the competitive and dynamic nature of the sector, and considering that the number of aircraft in the sky will double in 15-20 years, especially manufacturing companies need to grasp the increasing importance of Industry 4.0 and take advantage of the changes and opportunities that the digital revolution will bring. At the same time, it is of great importance for businesses to keep up with Industry 4.0 and adapt their production systems to new technologies in order to maintain their competitiveness in global markets.

Adapting new technologies such as the Internet of Things, renewable energy, and smart factories to the aviation industry is very important for the future of the industry. Over time, manufacturers will benefit more from advanced Industry 4.0 applications in matters such as cockpit management, aircraft production and maintenance. With Industry 4.0, transparency and real-time data analysis will play an active role in reducing costs.

2. INDUSTRY 4.0 AND DEVELOPMENT

The emergence of the concept of Industry 4.0 is with an advanced technology themed project carried out by the German government. The project has been prepared with the approach of computerization of production. Inspired by the important transformations in previous industrial revolutions, the project named the new era as

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Industry 4.0. The concept was used for the first time at the Hannover Fair in 2011. In the theoretical dimension, Industry 4.0 came to the fore for the first time with the article titled “Industry 4.0: On the way to the 4th Industrial Revolution with the Internet of Things” published by Kagerman et al. in 2011. In the article, it is stated that the world has entered a new period and this period should be described as Industry 4.0, and information is given about the components that make up this process. Later, with the report titled "Recommendations for the Implementation of the Industry 4.0 Strategic Initiative" published by the German National Academy of Sciences and Engineering (Acatech) in 2013, the subject gained a formal framework in the theoretical dimension (Soylu, 2018: 43).

In the third industrial revolution, the producers continued on their way with the understanding of production they took over from the previous industrial revolution. The main purpose is to make life easier. Different devices (eg home appliances) developed in different sectors are always aimed at this purpose. Later, with the gaining importance of electronics and information technologies, which started to enter daily life at the beginning of the 1970s, the increasing automation in manufacturing brought new dimensions to the next level (Özsoylu, 2017: 44).

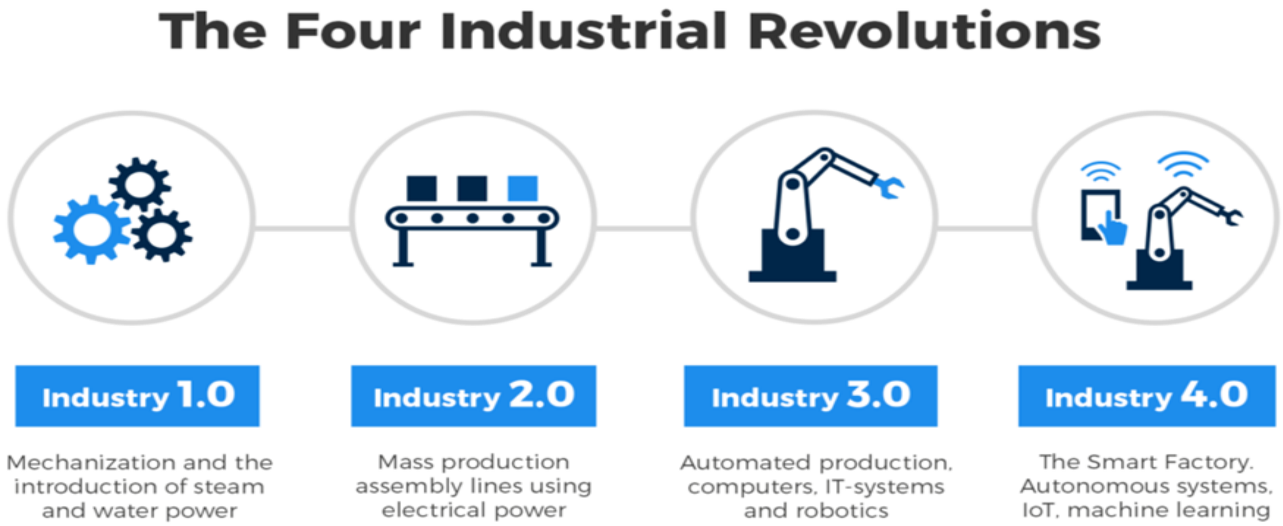

Figure 1. Historical development of the industry
Source: https://kfactory.eu/short-history-of-manufacturing-from-industry-1-0-to-industry-4-0/

Every product of information and communication technologies that people use at every stage of their daily life, 3D-printers, unmanned aerial vehicles, computers and smart devices used in smaller but faster and larger data transfer have been the driving factor in the transition to Industry 4.0 (Biçer, 2018: 130-131).

The first industrial revolution can be expressed in general terms as a number of scientific and technical developments that emerged in Great Britain towards the end of the 18th century. Production in this period; It has started to be done thanks to the adaptation of water and steam power to the machines (Öcal and Altıntaş, 2018: 2069).

Steam engines were used in the first trains, boats and agricultural machinery within 30 years. While the steam engine was a driving force of the First Industrial Revolution, the textile industry was another force. The main facilitating technologies of the First Industrial Revolution are the change in power sources (steam engine working with coal and wood fuel). The First Industrial Revolution focused on textiles and iron making. It also sought to increase productivity in production, used mechanical tools that depended mostly on muscle power, with life cycles for decades, adopted a subsistence standard of living, and made its first impact in England in 1750 (Topsakal, Yüzbaşıoğlu and Çuhadar, 2018: 1625).

The second industrial revolution emerged at the beginning of the 20th century with the emergence of the need for renewal in the field of industry. In this period, the importance of fossil fuels increased gradually, there were developments in the field of transportation and communication, and the use of electricity increased. Although many sources accept that the second industrial revolution took place between 1870 and 1914, some sources state that the work that paved the way for the second industrial revolution started in the 1850s (Barutcu, 2019: 5).

The most important factor in the emergence of the second industrial revolution is the ease of access to distant markets and the supply of raw materials with the development of railway transportation. In addition, the change of energy sources and raw materials used, and the advancement of technology day by day constitute the foundations of the second industrial revolution (Pamuk and Soysal, 2018: 42).

Considering the third industrial revolution, the development of mechanical and electronic fields has been ensured by mass production with electricity, and tools and information technologies that can be programmed through digital technology have emerged. In the middle of the 20th century, progress was made in heavy industry and information technology, and thus a new term called "information society" emerged. This also made possible the production of chip technology, fiber-optic and microelectronic technology and enabled the development of atomic energy (Bulut and Akçacı, 2017: 52).

3. COMPONENTS OF INDUSTRY 4.0

3.1. Cyber Physical Systems

Cyber-physical systems, by establishing a connection between mechanical and electronic components through information technologies, ensure the communication and continuity of each of them within a network system. Industry 4.0 environment is completely surrounded by internet infrastructure and components. All kinds of transactions, from logistics activities to information data security, from business environment to social networks, are under the influence of artificial intelligence and information technologies. The principle of “interoperability” in Industry 4.0 design is the most important feature that can be provided by all components. Thanks to the virtual office and remote access opportunities, time and place constraints are eliminated in order to do business together. The principles of "virtualization" and "distribution of responsibility" are realized through Cyber-Physical Systems and Smart factories (Rpa4turkey Web Page, 2021).

3.2. Internet of Things

The concept of the Internet of Things was coined by British entrepreneur Kevin Ashton. The idea was formulated in 1999 to express a system in which objects communicate with computers (exchange data) with ubiquitous sensors. In this form of approach, not only objects, but also processes, information, atmospheric phenomena, people and even animals are considered as a variable and a system is formed from everything (Witkowski, 2017).

From a technical point of view, the Internet of Things is a collection of physical artifacts that cover both electrical and mechanical and embedded systems of computer and communication mechanisms that provide internet-based communication and data exchange (Yıldız, 2018: 550).

3.3. Internet of Services

The concept of the internet of services emerged based on the idea that services are made very easily accessible thanks to the internet and web technologies, allowing businesses and private users to bring together, create and deliver new types of value-added services. In the coming timeframe, businesses will use internet platforms to set up and provide many new types of services that transcend services such as booking flights or purchasing boks (Toker, 2018: 55).

3.4. Renewable Energy

Solar and wind energy, geothermal energy obtained from groundwater, wave energy obtained from seas, biomass energy obtained from biological wastes, hydrogen energy obtained from rivers and water are self-renewing energy sources. These energy sources are more preferred in today's conditions, as they are cheaper and easier to obtain than coal, oil and other similar sources. This shows us that industry 4.0 is increasing day by day (Aydın and Demiral, 2019: 1980).

3.5. Smart Factories

The emergence of smart factories and the advanced technology automation systems in use will reduce the need for low-skilled labor. With the new arrangement, it is aimed to minimize the error rates in the production phase, to accelerate the production process and to reduce the expenses during the production. Among the benefits of smart factories, individuals are able to order a special product or make their own design during the creation of the most tangible form of the product before it is produced or before the product reaches its final state (Pamuk and Soysal, 2018: 47).

4. CIVIL AVIATION AND INDUSTRY 4.0

The first evolutionary stage, Aviation 1.0, did not have commercial aviation markings to help pilots fly at this stage. This period was a period of technological difficulties in terms of how the aircraft should be produced and flown and mechanical inventions began to appear. This era was dominated by the technological challenges posed by how to build and fly an aircraft.

The second phase, aviation 2.0, was instrumental in replacing old mechanisms with electrical devices. Technological advances at this stage were affected by two major challenges: 1-How to use an aircraft in bad weather conditions. 2-How to control planes in busy airspace. Innovations in aircraft such as electric autopilots, weather radars and navigation devices emerged in this period. New instruments such as the VOR (very high-frequency omnidirectional range) and ILS (instrument landing system) allows the pilots to follow safely tracks and approach paths.

Aviation 3.0 was the third stage in the commercial aviation revolution. At the start of this revolution, obsolete instruments were replaced with color displays, clearing the confusion of instruments in the cockpit. This third revolution in aviation gave rise to the concept of "electronic ecosystems". Technological solutions were progressively designed to support the operators informed decisions, with the help of aggregated, visualized, understandable information (Valdés, Comendador, Sanz, Castán, 2018).

Aviation 4.0 deals with cyber-physical design. Cyber-physical systems aim to increase the amount and variety of operational data that can be collected on the aircraft by making aircraft systems digital and intelligent. Aviation 4.0 is concerned with the design of cyber-physical Systems (CPS) that are able to assist humans demanding work by helping them to take decisions and to complete tasks autonomously, and with its integration of cyber-physical components in future aviation information systems (Mosterman and Zander, 2016).

Industry 4.0 technologies (automation, artificial intelligence, cognitive computing, big data analytics, digitization, etc.) produce new mechanisms that are not only more efficient but also safer.

Today's digital technologies make product lifecycle data available and adaptive in real time. To compete in the global market, aviation companies need to stay up to date. To achieve this, they must develop faster, cheaper and better products. The only way to do this is to use the new digital tools offered by Industry 4.0. On the other hand, Industry 4.0 will enable companies to reduce costs, improve quality, increase throughput, minimize waste and increase opportunities to introduce new products.

In the past, the manufacturing process in aviation required products to be brought together piece by piece from the production line, and then transported through extensive testing. This has resulted in significant inefficiencies. If the product did not work correctly at this stage, the product had to be remanufactured and tested, resulting in serious delays in production and increased costs. Now with the introduction of new production line technology, downtime is minimized and cost is reduced as manufacturers can see every part of the process in real time. Investing in digital technology may seem expensive in the short run. However, digital technologies will be very beneficial in the long run as this technology helps manufacturers avoid test errors, wasted time and problems that result in increased costs. Tomorrow's workforce and the best talents will be owned by companies using the latest technologies. Companies operating in the aviation industry need to adopt digital technologies in order to survive and keep up with other markets. Industry 4.0 has become a necessity rather than a desire for the aviation industry (Aero-mag Web Page, 2021).

4.1. Aviation 4.0 Concept to Increase Safety Levels in Aviation

- ✓ Development of a robust predictive aircraft maintenance system:

Reducing the probability of an accident by collecting information about the technical condition of the aircraft with many sensors on the aircraft and notifying the relevant people about the maintenance required on the aircraft automatically and in real time.

- ✓ Predefined automatic flight with rule-based method:

In an airplane crash in 2002, the on-board computer detected the risk of collision with the TCAS system, calculated the appropriate maneuvers and gave an alarm. Despite this, the flight crew did not evaluate this warning and the accident occurred. If the aircraft had maneuvered automatically, the accident would most likely not have occurred.

- ✓ Cognitive computing assistance systems for cockpit safety:

To help the flight crew especially in crisis and emergency situations by copying the human thinking system of the flight computer.

- ✓ Real-time weather information update.
- ✓ Advanced search and rescue services, especially in ocean or remote areas (Jankowska, Di Maria and Cygler, 2021).

4.2. Aviation 4.0 Concept in Aircraft Productıon

4.2.1. Robotics

Aircraft production is one of the most important branches of durable consumer goods production because of its high added value. Errors should be avoided when investing in aircraft manufacturing due to the exorbitantly high cost of developing new products. Increasing demand from airlines that transport passengers or cargo has driven aircraft manufacturers to seek to improve processes to increase productivity. Therefore, the concept of Industry 4.0 has been the input to make innovation and business more competitive in aviation manufacturing. Robotics improve the quality of work by taking over dangerous or tedious jobs that humans cannot do or lack confidence in. High performance and low investment cost make robots the perfect choice for an efficient and easy automation solution. Especially in recent years, aircraft manufacturers tend to use robots in some manufacturing applications to perform tasks that require precision and robustness in large parts (Journal of Steel Structures & Construction Web Page, 2021).

4.2.2. Simulators

Simulator systems are used in the production phase as well as in every field of aviation. These; System Integration Laboratory: As a research and development process support tool such as efficiency analysis and performance testing of a developed system or subsystem. Prototyping: For ergonomics and performance analysis, task analysis, interaction with other elements and motion modeling (Mmo Web Page, 2021).

4.2.3. Smart Factories

Equipment failures in all production facilities damage the production process and lead to losses. Intelligent sensors used at every stage of the production process can monitor the status and needs of equipment in real time. The analysis of this data ensures that problems are detected before they occur, prevents unplanned failures and minimizes maintenance and repair costs. Maintenance workers can consult remote specialists with virtual reality glasses. The recordings made by the glasses mean training opportunities for remote workers. Augmented reality systems, on the other hand, go one step further, allowing technicians to intervene from where they are without going to the malfunctioning machines (GG Türkiye Blog Web Page, 2021).

4.2.4. Augmented Reality (AR)

Augmented reality provides a new perception environment by placing elements used in digital techniques such as computer-generated animation, sound, image and hologram into our environment in real time through smartphones, tablet computers and virtual reality glasses (Bingöl, 2018: 46).

In aviation, the benefits of using AR are innumerable. AR applications help pilots, crew and other personnel avoid costly mistakes and make the right decisions to save lives. As a pilot prepares to board a plane, the Head-up Display (HUD) based on AR technology creates a virtual checklist to assist with pre-flight checks. After the check is complete, it displays the runway information. The pilot can even receive alerts about landing, landing or other flights with taxis. As an aircraft approaches the ground during landing, AR systems provide guidance to pilots on what to do, taking into account emergencies, and reduce take-off and landing risks. AR can display relevant information including weather update, flight plans, waypoints, artificial horizons and terrain details to increase awareness (E learning Industry Web Page, 2018).

4.2.5. Radio Frequency Identification (RFID)

Radio Frequency Identification (RFID) is an automatic identification technology that should gain acceptance in many industries, including aviation. It provides benefits beyond barcode technology. Barcodes need light to transmit and receive data, while radio waves are used to transmit data from an RFID tag. The function of these radio waves is to pass through, around, under, and behind objects to reach a label. At the same time, since the technology can see hundreds of tags per second, there is instant data collection. This provides a new opportunity for airlines. For example, it can be quickly determined whether there is a life jacket under each aircraft seat or if any life jacket boxes have been compromised. A complete RFID system requires several components: The RFID tag includes an antenna to send radio signals, a reader attached to the antenna to decode digital signals, and a computer system to control the process (Skybrary Web Page, 2021).

4.3. Aviation 4.0 Concept in Aircraft Maintenance

Technologies that may be of key importance for the aircraft maintenance industry are offered by Industry 4.0. Technologies such as networking, the use of big data, personalized and non-local production capabilities, interconnected micro-sensor networks, intelligent and intuitive visualization of data and information in remote operations, automation are among the key technologies that can increase efficiency and speed by increasing efficiency and speed not only in factories but also in the aviation industry. (Testoni, Marchi and Marzani, 2016).

One of the usage areas of engineering simulations, 3D printing and augmented reality applications is aircraft maintenance operations. These applications were used extensively in the design process of the Airbus A350 and Boeing 787 Dreamliner. Likewise, Pratt & Whitney is known to focus on investments in virtual reality engine maintenance training for aircraft mechanics on its training division. In addition, the product called Aero Glass offers augmented reality application for pilots in training and flights. In this direction, while Aero Glass provides navigation support to pilots, altimeter readings, runway approaches, fuel pressure, etc. It also simplifies many processes (Atalık, Akan and Bakır, 2019: 901).

4.4. Four Impacts of Industry 4.0 on the Aviation Industry

The pressure on aircraft production continues to build, fuelled by an increasingly significant surge in travellers. Nowadays, the transition to Industry 4.0 appears to be the most effective solution to boost factory productivity. Since the aviation industry is a sector with continuous production and the concept of productivity, it needs to keep up with Industry 4.0. New digital technologies, software and materials will be gradually integrated into the aerospace industry, which will enable new production tools to be installed in the coming years. Pascal Brier, Altran Group Executive Vice President of Strategy and Innovation, sheds light on the four major changes Industry 4.0 is leading in aircraft manufacturing (Ignition Web Page, 2021).

4.4.1. Unique Data System

Today, Enterprise Resource Planning is one of the systems that manages aircraft production and is independent of each other. With enterprise resource planning software, all operational processes of the institution are integrated and carried out with a single system, while data is recorded in a common database. Afterwards, these data are analyzed and transformed into meaningful information. While collecting data was the biggest problem for institutions in the past, now with professional enterprise resource planning software, data can be collected and reported effectively at every point where it is entered.

4.4.2. New Digital Production Technologies

Industry 4.0 means the development of new digital technologies. In the future, a few small digital machines equipped with sensors that can be remotely controlled and connected in real time to a control room will change the way companies invest and save money. The fact that all these new machines are digital will reduce error rates and time loss, and analysis of mechanisms will be easier thanks to artificial intelligence.

4.4.3. Central Control Room

The creation of a control room that will collect data from machines on the production line will monitor the activity of the entire production chain in real time and assist operators in their tasks. This makes it easier for companies to obtain the data stream they need to collect and analyze. Data can be monitored with a mobile mechanism at any place and time. E.g; data can be accessed from all machines by connecting to a factory in Spain in real time with a smartphone. These control rooms have many advantages. They provide real-time visibility and specifically offer the capacity to remotely control production to react to potential problems. Above all, they facilitate advanced data analysis and thus the creation of scenarios or simulations to predict how efficiency can be improved.

4.4.4. Interaction Between Humans and Machines

Robots gain access to difficult or sensitive areas. For example, they can approach high heat sources, electric zones, and the like. Therefore, they increase site safety for employees (Ignition Web Page, 2021).

5. CONCLUSION AND RECOMMENDATIONS

The aviation industry is a costly industry where safety and security are at the forefront. The slightest maintenance or usage error can cause serious losses. Airplanes are very costly for companies during production and maintenance. With the developing technology, the concept of Industry 4.0 has reduced the costs of aircraft production and maintenance activities, as well as pilotage and technical training. Therefore, companies need to give more importance to research, development and investment activities in this field. At the same time, people must have the digital skills to use these systems. For this reason, these companies should also focus on acquiring the necessary skills of their employees.

As a result of increasing competition, companies that plan future technological, product and market development should implement the Aviation 4.0 revolution and as a result, they should apply to technologies such as smart robots and cyber-physical systems in their factories. Tomorrow's workforce and best talent will be owned by companies using the latest technologies. Governments also have important responsibilities in this regard. In particular, providing infrastructure support to research and development studies is one of the most important responsibilities of governments.

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