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RESEARCH ARTICLE / ARAŞTIRMA MAKALESİ

The Impact of Industry 4.0 on Occupational Health and Safety

Endüstri 4.0'ın İş Sağlığı ve Güvenliği Üzerindeki Etkisi

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Abstract
When the subject is change, there are a few options: The first is to lead the change and make the rules, the second is to be a quick follower of the change and not to fall behind, and the third is to wait for the change to change you. Industry 4.0, as one of the largest drivers of change, makes its presence felt in all work fields and enables new applications to participate in different sectors. The main question here is how a multi-disciplinary and proactive domain like Occupational Health and Safety (OHS) will be affected by the winds of change in Industry 4.0. Technological developments have changed the substance of the problems and the variety of solutions in the OHS domain. In this paper, the components forming the substance of the Industry 4.0 philosophy are introduced, and good operational examples of these components in OHS have been investigated. The purpose of this study is to consider the effect of Industry 4.0 on the OHS domain and make it more capable of being defined in a theoretical context. Hence, the advantages and disadvantages of the subject are discussed by introducing Industry 4.0-based OHS applications for different sectors in Turkey. Expectations from employees in the transition to Industry 4.0 will change. Employees who can process digital data, who have knowledge about different disciplines and who are eager to work with the multidisciplinary fields will be the people are preferred in the new industrial age. However, this status will affect the social lives of the employees. New risks are expected to reveal different occupational diseases and accidents. Occupational health and safety measures to be taken by experts should be adapted to new standards and legislation should be updated to cover these issues.
Keywords: Industry 4.0, occupational health, safety

Öz
Söz konusu değişim olduğunda, birkaç seçenek vardır: ilki, değişime önderlik etmek ve kuralları koymak; ikincisi, değişimin hızlı bir takipçisi olmak ve geride kalmamak; üçüncüsü ise değişimin sizi değiştirmesini beklemektir. Değişimin en büyük öznelerinden biri olan Endüstri 4.0, tüm çalışma alanlarında varlığını hissettirmekte ve yeni uygulamaların farklı sektörlerde hayat bulmasına sebep olmaktadır. Buradaki temel soru İş Sağlığı ve Güvenliği gibi multidisipliner ve proaktif bir alanın Endüstri 4.0 değişim rüzgarından nasıl etkileneceğidir. Teknolojik gelişmeler, İş Sağlığı ve Güvenliği alanındaki problemlerin içeriğini ve çözüm yollarının çeşitliliğini değiştirmiştir. Bu çalışmada Endüstri 4.0 felsefesinin özünü oluşturan bileşenler tanıtılmış ve bu bileşenlerin İş Sağlığı ve Güvenliği alanındaki iyi uygulama örnekleri incelenmiştir. Çalışmanın amacı, Endüstri 4.0'ın İş Sağlığı ve Güvenliği alanına etkisini kavramsal çerçevede daha tanımlanabilir hale getirmektir. Bu nedenle ülkemizde farklı sektörlerden endüstri 4.0 tabanlı İş Sağlığı ve Güvenliği uygulamaları tanıtılarak konunun avantajları ve dezavantajları tartışılmıştır.
Anahtar Kelimeler: Endüstri 4.0, mesleki sağlık, güvenlik

I. INTRODUCTION

In recent years, Industry 4.0 is regarded as having created new value with developing technology and social expectations. Industry 4.0, which seems to be the preferred method for companies that aim to produce independent products internationally, also brings new approaches in manufacturing as well. Apart from the traditional meaning, data processing and transfer is carried out in a different dimension within Industry 4.0 [1]. Industry 4.0 defines the Fourth Industrial Revolution, a new level in the organization and management of the entire value chain of the life cycle of products and production systems. This cycle focuses on ever-increasing individual customer needs and includes all-in-one services that encompass product development and production orders, beginning with an intellectual phase and involve product end-user distribution and recycling. As resources decrease day by day worldwide and production volume increases, production systems are also changing. While there are many factors that cause this change, the main reasons are increasing costs, constant innovation expectations and increasingly global competition. With this new process called Industry 4.0, digitalization can be realized at every stage of production, making it possible to meet market requirements faster, more flexibly and more efficiently. It is known

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that production technologies are changing over time. Day-to-day manufacturing and manufacturing technologies from earlier times are being dynamically renewed. Producing goods and services efficiently is also important in terms of the competitive environment. A market economy makes competition compulsory, and businesses that produce goods and services are forced to deliver cheaper, faster and more efficient production. Otherwise – due to the competitive conditions – the business will not survive and will have to withdraw from the market. Management knowledge ensures that these businesses comply with such competitive conditions and suggests ways to take necessary measures to keep them alive [2]. At the new level to be reached with Industry 4.0, the connection of people, objects and systems will be common and efficient. Thanks to this, a dynamic, real-time optimized, self-organizing infrastructure will spread across the entire organization and form inter-organizational value-added networks. These networks will have the ability to optimize themselves according to various criteria, such as cost, availability and resource utilization. The emergence of mechanical industry in the industrial revolution of the 18th century formed the first industrial revolution, the discovery of electric motors in the 19th century spawned the second industrial revolution, and the introduction of electronic and information technologies in industrial systems underpinned the third industrial revolution and created the basis for Industry 4.0. The history of industry is shown in figure 1.

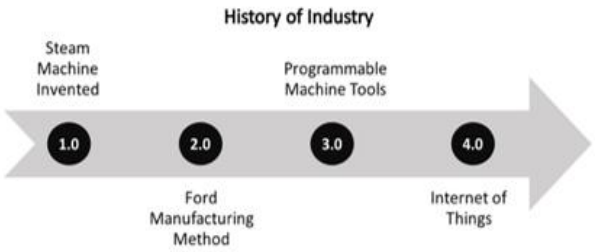

Figure 1. History of industry

All these industrial revolutions did not just influence production itself, but also the labour market and the educational system as well. Industry 4.0 is a term first used in the Hannover Fair in Germany in 2011 and in an academic article by Kagermann. After putting forward the main idea of Industry 4.0 by Kagermann (2011), a theoretical framework from the German Academy of Sciences and Engineering was published in 2013 as the "manifesto". In the final report of the German Academy of Sciences and Engineering Industry 4.0 forum, the distinguishing innovations that this new era is bringing about are:

- The global interaction of storage systems and resources with machines.
- The development of unique intelligent products with location knowledge.
- Intelligent factories that adapt to product specifications and provide resource optimization.
- The realization of new business models (new services resulting from the use of big data).
- New social infrastructure in the workplace for employees.
- Business structures sensitive to individual differences.
- A better work/life balance.
- Responding to individual consumer demands.
- Intelligent software developed for immediate engineering and instantaneous response to problems.

The European Commission's Industrial 4.0 paradigm, which internalizes the basic development in Germany, is shaped largely in three dimensions:

- Horizontal integration between value creation networks.
- End-to-end engineering in the product life cycle.
- Connectivity and vertical integration in manufacturing systems [3].

Industry 4.0 is considered to be the optimal digitization of the manufacturing sector and helps the emergence of analytical and business intelligence capabilities, new forms of human–machine interaction, such as touch interfaces and enhanced reality systems, and a new stream of improvements in the transfer of digital instructions such as 3D printing in the physical world. In other words, the production of intelligent products and services with intelligent robots in smart factories is known as the fourth industrial revolution. The latest technological change and transformation in the industry has begun with Industry 4.0 and continues at a rapid pace. Electronic information network systems (Internet) are at the core of this industrial revolution, and of Industry 4.0. Industry 4.0 emerges as a digitalization and automation of all processes of a company, and aims to bring this new technology to business models, product production chains and industry in general by combining intelligent product manufacturing processes with revolutionary embedded system technology.

Industry 4.0 delivers:

- Low-cost production
- Increased productivity
- Higher quality products and services
- Production with fewer errors
- Minimum production time
- Flexible production systems that can respond to customer requests more quickly are achievable.

The Industry 4.0 revolution is not only about smart and connected machines and systems, the scope is much broader. From nanotechnologies to renewable energy, simultaneous development in each field is being

experienced. It basically differs in that these technologies are intertwined and merged, and they interact in the physical, digital and biological fields. Beyond speed and breadth, Industry 4.0 is largely increasing alignment of different disciplines and research, and is also unique because of its integration. The effects of the Industry 4.0 revolution we live in will determine the level of competencies in every area up to strategic goals. Therefore, in recent years, academic studies have been carried out in many fields from science to law and from industry to economics. In addition to the many advantages that Industry 4.0 brings and will bring in, some of the disadvantages should be mentioned. As known, occupational health and safety (OHS) is a set of processes aimed at reducing all employee-related risks to the minimum possible level. OHS is a proactive and multidisciplinary field. This field is very suitable for innovations and technology use. Thus, Industry 4.0 applications in the field of occupational health and safety are widely available. In this study, the components of Industry 4.0 will each be explained, and Industry 4.0 applications used in the field of OHS will be discussed to highlight the advantages and disadvantages with respect to OHS. The rest of this paper is organized as follows. Section 2 includes the definitions and the preliminaries on Industry 4.0. Cyber Physical Systems, Internet of Things, Big Data, Cloud Systems, Cyber Security and Virtual Reality which are the components forming the substance of the Industry 4.0 philosophy are introduced. Section 3 summarizes the findings the good operational examples of these components in OHS. Section 4 discusses the new risks are expected to reveal different occupational diseases and accidents. Finally, the study is concluded in the last section.

II. METHODOLOGY

When considering the innovations and working principles of Industry 4.0, it is clear that cyber physical systems, big data, the Internet of Things (IoT), virtual reality and cyber security are very closely related. This relationship also considers what each stakeholder needs to do in order for the system to progress seamlessly. The components of Industry 4.0 are shown in figure 2.

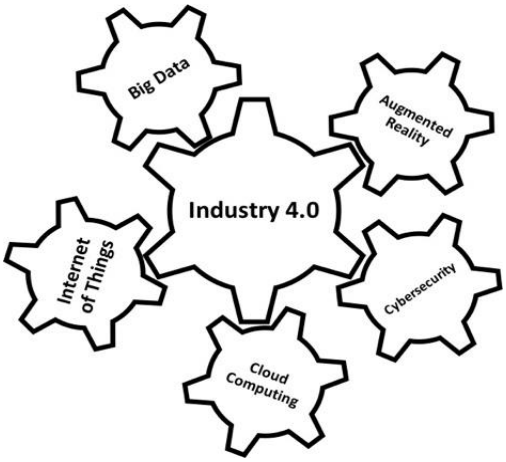

Figure 2. The components of industry 4.0

2.1. Cyber Physical Systems and Industry 4.0

The new process, referred to as Industry 4.0, has a structure that will completely change production and consumption relationships. Industry 4.0 includes systems in which sensors, machines and robots communicate with each other over the internet, simultaneously collecting massive amounts of real-time information and storing them using cloud-based technology. These systems, which are connected via the internet and stored using cloud technology, are called Cyber Physical Systems. These systems, supported by sensors, involve the interaction of objects in the physical world with their internet services and global interaction [4]. The concept is derived from the scientific discipline known as “cyber”, which is the subject of research on the communication and control of living beings and machines. In the 1970s the concept of “cyberspace” was often used to describe control processes based on information technologies, computers and the Internet [5]. The concept of cyber physical systems was first used by Lee in the US in 2006 to emphasize the growing importance of computer systems linked to the physical world. Cyber physical systems include mechatronic components equipped with sensors that collected data about business movements affecting physical processes. Cyber physical systems are intelligent systems in which ever-changing data are simultaneously linked together in a virtual cloud system. As part of the socio-technical system, cyber systems use a humanistic machine interface for the production process [6]. Industrial automation systems describe computerized manufacturing processes that enable physical production processes to be managed through a monitor. The cyber part of the system consists of computer software that takes data from physical processes and adapts this data to the production process [7]. Cyber physical systems are one of the key components of Industry 4.0. Collectively, the technologies enable continuous communication and allow a ceaseless trade of information and interaction between people and machines, and between machines themselves. The main component of the cyber physical system is the ‘Embedded Device’. An embedded device consists of hardware and software integrated into a mechanical or electrical system (or object) that is designed for some purpose [8]. A cyber physical system is a collection of these embedded devices that communicate with one another and interact with the physical world via sensors and actuators in a feedback loop. The cyber physical system leads to a more ubiquitous use of computing capability, and embedded devices can be included in almost every engineered product. The efficient use of cyber physical systems with high functionality enables rapid growth of Industry 4.0. Industry 4.0 aims to work independently of time and space and also at optimum efficiency. Cyber physical systems that serve this discipline are seen as an effective aid to it. As a result of the integration of cyber physical systems with production, logistics and services, it will be possible for

today's factories to be transformed by Industry 4.0 into factories with significant added economic potential.

2.2. Internet of Things and Industry 4.0

The communication and interaction that the components of production establish with each other is provided through the internet. The Internet of Things (IoT) is where objects can communicate with each other. The concept of the Internet of Things (IoT) used by Kopetz (2011) explains how data can be collected, duplicated and organized from different sources in a workplace or factory. The Internet of Things offers an interconnected data management that speeds up process controls. This platform effectively uses big data to transform the knowledge of the cyber physical system actions. The changing data has the potential to create value in different layers of the business channel chain [9]. The IoT is a special case of the cyber physical system where the medium of network communication is the internet. The term 'Thing' refers to scenarios where network connectivity and computing capability extends to objects (things), sensors and everyday items not normally considered computers. The 'Things' generate, exchange and consume data with minimal human intervention. Such objects are equipped with ubiquitous intelligence and form a highly distributed and heterogeneous network. Because the communication medium is the internet, the objects are not confined to a restricted geographical area but could exist, in principle, anywhere. Through the IoT, the network could include globally distributed manufacturing sites and the supplier base. Developments in Industry 4.0 are now having an impact on the manufacturing industry. The Internet of Things (IOT), also called the industrial internet, forms the basis of smart factories, intelligent products and intelligent services [10]. The concept of the Internet of Things includes systems that perform the functions of decision making, communication, management and movement with the aid of sensors located on various systems. Such systems not only work on their own networks but also communicate with other electronic networks. A device shares business and services on its network with other networks and follows requests and news from other networks. It is expected that the ability to make decisions, manage and act on such transactions should be according to certain rules. On the one hand, the production systems that adapt to the changing needs of the consumer on the fly and on the other side depicts the characteristic structure of the new era where automation systems are in constant communication and coordination with each other.

2.3. Big Data, Cloud Systems and Industry 4.0

The main vision for Industry 4.0 is the emergence of "smart factories" that will be connected to the production facilities of cyber physical systems, using machine–machine, human–machine or human–human communications, and at the same time use an enormous amount of data obtained via Industry 4.0. For this reason, it will be necessary to analyze big data to be able to predict possible failures and adapt in real time to changing conditions. The philosophy of Industry 4.0 requires communication between industrial vehicles. This communication, which takes place via the internet, requires very large and traditional servers. This problem increases the importance of research on big data technology, which involves controlling and directing systems [11]. New developments in cloud technology have changed the way manufacturers and their consumers think. Cloud systems and big data have led to radical changes in the basic structure of business and application models, and now it is one of the most popular concepts of this age. Improvements in computer and memory systems have made it possible to collect and store data in very large amounts. The cyber physical systems and the Internet of Things make it possible to transfer data to physical systems that reach enormous dimensions. Big data systems decrease the need for servers to be kept by companies and provide access to the information needed for production. Together with that, big data systems enable the public nature of information to be more visible, thereby providing a number of cost advantages for companies, while also affording a lower price advantage for consumers. With the help of cloud systems, Industry 4.0 has the potential for placing the factory right at the heart of a highly distributed network of customers, retailers, suppliers and any other interested stakeholders.

2.4. Cyber Security and Industry 4.0

The products produced with the Industry 4.0 system are smart products. Based on connectivity, information exchange and computing power, the main idea behind smart products is that they control the production process themselves. The fact that big data systems are open to internet access makes the point of cyber security for these platforms a very important topic. Cyber security is protecting virtual systems against all kinds of attacks and threats. Cyber security also determines the security risks and weaknesses in cyberspace, institutions, organizations and users from undesired threats and takes precautions by making necessary security analyses. The main purpose of cyber security is to protect the confidentiality of the information processed, stored and transferred in the information systems, the integrity of the data, the information access, the protection of the speed and quality, and the continuity of the system. The interconnected nature of Industry 4.0-driven operations and the pace of digital transformation mean that cyber-attacks can have far more extensive effects than ever before, and the reality is that manufacturers and their supply networks may not be prepared for these risks. For efficient operation of Industry 4.0 in all areas, the cyber security rationale must be regularly refreshed, flexible and practical.

2.5. Virtual Reality and Industry 4.0

Monitoring of actual processes and machines takes place in the physical world. In Industry 4.0, these

processes may be linked to virtual models or models created through simulation. Industrial engineers and designers can then customize, change and test changes or upgrades in a completely isolated way without affecting the physical processes they virtualize. Manufacturers involved in Industry 4.0 installations can create a "virtual twin" of the smart factory to greatly improve existing processes and products, and reduce the time needed for product development and modelling, create a manufacturing process, and thus reduce the cost of new products. Before the advent of Industry 4.0, if it was desired to test whether a production process was working efficiently and effectively, trial and error was required. In Industry 4.0 systems, a digital twin of the production process can be created by simulation modelling and testing using virtual reality, and so, product quality as well as production can be controlled by the digital twin version.

III. FINDINGS

The effects of the Industry 4.0 revolution we are living through will determine the level of competencies in every area up to strategic goals. Therefore, academic studies have been carried out in many fields from science to law, from industry to economics in recent years. In addition to the many advantages that Industry 4.0 brings, and will bring in, some of the disadvantages should be mentioned. As known, occupational health and safety (OHS) is a set of processes aimed at reducing all the problems related to employees to the minimum possible level. Being healthy is defined as being physically, spiritually and socially complete, so it can be said that when all these states of well-being exist together, one is fully healthy. Physical health means no illness, disability, or having a disease risk factor in the body; mental health means knowing how to act according to the age and situation of the person, and social health means that the person creates a language that is understandable within the environment they live in and performs a role in society according to the needs of the society in which they live. A deterioration in any of these areas will lead to disruptions and imbalances in the other aspects. This indicates that the factors that make up health are not completely independent from each other, but tend to act as a whole. OHS is a multidisciplinary field that takes proactive measures against work accidents and occupational diseases, informs employees, organizes training, conducts risk assessments and carries out activities to regulate the working life to the extent required by labour laws. OHS, like all other fields of study, is affected by developments in technology, and the innovations brought by Industry 4.0 have the opportunity to be applied to OHS. Therefore, it will probably be necessary to interpret OHS from a new perspective. Leso V et al studied in their paper to provide a comprehensive overview of the opportunities and problematical aspects of Industry 4.0 in relation to the health and safety of workers [12]. Thanks to the integration of the basic building blocks of the OHS 4.0 digital transformation process into the field of occupational health and safety, it is interpreted as a new trend aimed at proactively protecting the health and safety of employees by maximizing human and machine compliance with safety procedures.

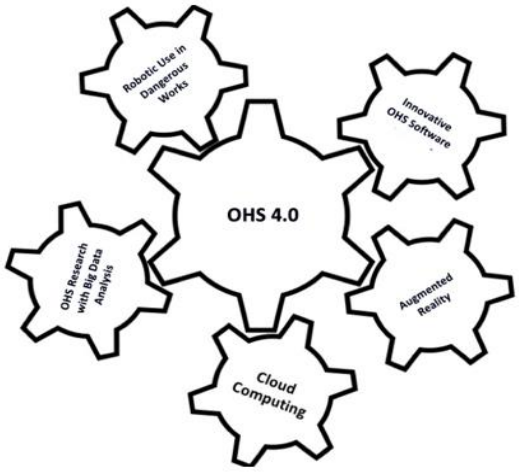

Figure 3. The components of OHS 4.0

This trend finds a response in business life, and the way of doing business also changes in the field of OHS. For example, the Internet of Things (IoT) technology has started to be used, for personnel tracking especially, in the field of OHS. It is thanks to this technological development that personnel follow-up in mining for coal is possible and access to facilities such as location detection at the time of an accident can be achieved. Another example of OHS 4.0 study is in virtual and augmented reality applications. It is possible to transfer many activities such as working at height, fire training and case analysis to employees with virtual and augmented reality applications, and to achieve better performance than the classical method. The components of Industry 4.0 that are used for OHS are shown in figure 3. With these technologies being integrated into our lives more and more every day, an innovative period has started in OHS training, and simulation technologies, including time, space, equipment etc., help eliminate many constraints. It has also been stated by employees that the permanence and quality of the training has increased.

New technological developments are needed in order to overcome the difficulties encountered with OHS in order to decrease the cost and to increase the security. Therefore, it is very important to use the innovative technologies that Industry 4.0 can bring to deliver effective OHS applications to business life. When it comes to OHS, the rhetoric such as "wear your hard hat" and "wear your gloves" are now replaced by completely different concepts, and the perspective of OHS practices change. To achieve this, a multidisciplinary approach needs to be adopted including on the expertise of a team comprising engineers, IT experts, psychologists, ergonomists, social and occupational scientists, medical practitioners, and designers [13]. It is relatively easy to

ensure the safety of workers in traditional production environments where a uniform product is manufactured. Safe working environments can be created thanks to the planned improvement works related to the risks identified through a risk assessment and trained employees with the necessary competence. If the correct procedures are prepared and implemented, hazards will be minimized and existing risks for the safety of employees will be eliminated. However, there are potentially many different and complex challenges in a production environment operating in a hybrid system. While reconstructing production areas in a short time, rapid changes in the tools and even the physical movement of the equipment can pose a number of security issues that may require a separate risk assessment for each of the configurations to meet potential requirements. In addition, systems that will ensure the security of processes, employees and data will need to be installed. Thanks to the systems developed with Industry 4.0, data can be collected in real time and then used in a timely manner without potential danger arising. When a number of devices are installed in the equipment that can detect and report the behavior of the operator, this device can be used to determine the quality of the air in the environment, the weight of the load being lifted, the working angle of the equipment, the noise in the environment, etc. It can specify the parameters that may work and pose a risk for the process. In this way, data related to the physical and biological properties of the operator and the environment are obtained during the study and these data are analyzed and evaluated. When acceptable limits are exceeded, the activity is stopped by giving a warning [14]. Innovations such as moving most of the training to virtual environments, simulating the events with different scenarios, producing in-house applications and making them available on mobile phones are considered as contributions of Industry 4.0 to OHS. Using big data technologies for OHS and trying to identify the risks with the data sets becomes more popular day by day. Industry 4.0 means a real-time interaction between humans, machines and products for developing smart production models where the products are specialized via digitalization for maximum flexibility. Industry 4.0, with human–computer interaction, also aims to provide production with exact punctuality, minimum costs and maximum efficiency. It is considered that repetitive tasks performed by robots will allow human resources to be allocated to more appropriate tasks and reduce occupational accidents to a minimum, especially in domains where the accident risk is high when machines and humans work together. The Industry 4.0 components, cyber physical systems and robots provide opportunities for reducing occupational accidents and accident risks. There are several examples on this subject. The "Risk Seizure in Virtual Environment" application of Tofaş Turkish Automobile Inc. requires the employees to enter a virtual auto-paint section with augmented-reality glasses and detect the risks in the environment. The risks the employee detects in the environment gain points for the employee, and after this process they get a certificate. Anatolian ISUZU Inc. operates the application programs Ergonomics Measurement Area and Ergonomics Central. OHS experts and also physiotherapists carry out duties here. With the application that Beyçelik Gestamp Automotive Inc. put into practice, an electronic sensor is placed in every working cell, and in case that the employee enters the wrong cell – by using a transmitter required for every employee – the process in the cell is forced to stop. A firm called BSH has realized a first in the world with the "smart ramp" application. In this ramp safety application, there is a safety mat in the area where the car approaches that senses living beings and tire-stabilizing barriers appear if there are any living beings are nearby, so the car is prevented from moving backwards or forwards. Furthermore, there is a moving ramp latch extending from the depot to the vehicle, so forklift trucks can carry weights right into the vehicle. Finally, there are lights that the vehicle can see on large screens; the red light signals the vehicle not to move, the green light signals that the loading is complete, and the vehicle may move. HEMA INDUSTRIES Inc. developed software for preventing problems such as musculoskeletal disorders, objects being dropped onto feet, and hands being squashed, during apparatus replacement. With this software, the worker enters the information for the desired apparatus into the screen. The robot brings the apparatus defined in the system to the worker and performs the replacement. ARÇELİK Inc. brought the Ergomatik application into operation to avert all repetitive actions and prevent ergonomic discomforts. With this application, heavily repetitive actions in a shift or a day are calculated, and all manual processes are cancelled. For example, during the production of an air conditioner, the silicon spraying process is repeated 800 times a shift, the body labeling, stenciling and drying processes are repeated 10000 times a day. Palm top power is used 2000 times a day and musculoskeletal disorders occur due to repetitive hand–wrist movements. With the application the firm put into practice, all these processes are now beginning to be handled by robots. A decrease in work accidents and occupational illness notifications has been observed. Examples such as BORUSAN LOGISTICS Inc.'s education of employees regarding working-at-high-altitudes via augmented reality, TURKCELL Inc's mobile application regarding OHS education being available on all the employees' cell phones and tracking their education using this application are the points where Industry 4.0 and OHS converge. Updated software and virtual reality applications preferred in management systems are other examples of applications in the OHS domain. Management systems and software such as Iova, Akare and Qdms are used more and more by the day in the OHS domain so that reporting procedures are facilitated [15]. Some application examples of Industry 4.0 that are used for OHS are shown in table 1.

Table 1. Some application examples of industry 4.0 used for OHS

Program/ Application Name	Usage	Purpose	Users
Besafe	Within Company	All reports regarding OHS * Monthly statistics (man hours, education hours) * Accident and close-encounter reports * Dangerous situations, acts and goods operation notifications * Fuel consumption * Managers monthly OHS-Environment report * Pandemia statistics tracking	All Functional Managers
SAP	Within Company	Annual environment report	OHS-Environment Manager
VR (Virtual Reality)	Within Company	A virtual reality program in which 5 deadly risks in pavement construction work are simulated	All Employees
Workplace	Within Company	Medical report tracking of employees	OHS-Environment Unit
Envepo	Within Company	Equipment tracking application (Machine control list, maintenance and malfunction tracking)	Machine Equipment Unit and OHS-Environment Unit
Teams	Within Company	Sharing program for communications, meeting, and all documents within company	All Managers
Bluejeans	Within Company	International education, seminar and meeting program	All Managers
Driver Risk Management	Within Company	A program measuring driver's risk levels and giving education towards enhancing their risk perception	All Drivers
Wranx	Within Company	A program which educates managers in construction tasks, provides education in every subject, conducts tests, awards badges to people according to level of achievement, and shows OHS education success stats	All Managers
Risk Seizure in Virtual Environment	Within Company	Risk identification program in virtual auto-paint section environment	All Employees
Ergonomics Central	Within Company	A unit which determines ergonomic measurements and conducts treatment and rehabilitation studies with regard to occupational illnesses	All Employees
Electronic Sensors	Within Company	Transmitter preventing worker entering working cell	All Employees
Smart Ramp	Within Company	Safety mat, tire-stabilizing barriers, ramp latch	All Employees
Workpiece Replacement Robot	Within Company	Software for preventing problems such as musculoskeletal disorders, items being dropped on feet and squashing of hands during workpiece replacement. With this software, the worker enters the information for the desired workpiece into the screen. The robot brings the workpiece defined in the system to the worker and performs the replacement.	All Employees
Ergomatik	Within Company	The Ergomatik application is used to avert all repetitive actions and prevent ergonomic discomfort. With this application, very repetitive actions in a shift or a day are calculated, and all manual processes are removed.	All Employees
VR (Virtual Reality)	Within Company	Giving work-at-high-altitudes education to employees via VR	All Employees
Mobile OHS Education Application	Within Company	OHS education tracking of employees	All Employees
IOVA, AKARE	Within Company	Management systems tracking	OHS Unit

IV. DISCUSSION

With the world transitioning to Industry 4.0, the management systems in factories are changing. Employees may work in factories or offices provided by the employer, as well as from a place outside the factory that is not provided by the employer. This change in working life can cause many potential problems in the field of OHS. First of all, the decrease in the number of employees in the factories, and the increase in the use of machinery requires changes in the measures to be taken by the employer in order to prevent occupational accidents. In terms of OHS, the decrease in the number of employees will reduce the number of workplace physicians – required by law – and also the time the workplace physician works will decrease. Industry 4.0 means less contact between workers and machines, which will reduce machine accident rates. Traditional production line workers and knowledge workers their tasks will merge more than ever. The processes will need various different new solution systems. This means management and production processes will become even more automated. Employees know where and when they do things, will be able to design their working lives themselves by calculating the access schedule. These social lives of time and value will be reflected. However, having continuous access to jobs also has the potential to create some psychological problems in the future. On the other hand, the increase in the number of people working in offices will increase the risk and rate of work accidents or occupational diseases in offices. The possibility of working from abroad will raise the problem of which country law to apply to any dispute. In remote management outside the factory, the employer must have informed the worker about occupational health and safety measures, provided the necessary training, supervised health and provided the necessary equipment, but when a worker operates remotely and works in a comfortable environment such as their own home, they are less likely to follow these instructions. In such a case, it will be difficult to prove that the accident occurred due to work. Changing the way of working will also change the existing OHS risk factors for employees. Among risk factors, the physical risk factors that are expected to remain important with Industry 4.0 include noise, vibration, lighting, thermal conditions, pressure and radiation will remain. However, more detailed OHS measures may be required for the protection of the eye health of workers regarding illumination. Industry 4.0 will decrease the rate at which the effect of microorganisms will be considered a biological risk factor of using machines in the production process. Increasing the number of machines in production sites may result in increased dust and gas density. Therefore, regulations regulating these chemical risk factors will need to be updated. In the Industry 4.0 system, it is estimated that the rate of psychosocial risk factors, such as precarious labour contracts, an aging workforce, job concentration, disruption of work and non-work life balance, group bullying and time management, will increase. Ergonomic risk factors will become more prominent as the time work pattern will change for employees. In Industry 4.0, there is a principle of continuous operation in smart factories in order to get maximum efficiency in production. In order for the factories to work continuously, the employees must work in shifts. This situation will bring with it a disruption to work and non-work life balance for employees. In other words, the employee will not be able to keep to a fixed routine in the shift system. Non-standard employment, shift work, daily rhythm disturbance, and maybe the most important one, social disconnection, are the other problems that will occur. In addition, the use of information systems in production means the private life of the employee can be more intertwined with business life, and the distinction between private and work life will become blurred for the employee. The effect of this situation on the employee will manifest itself as a psychosocial risk factor. Kocaay studied possible effects of Industry 4.0 to work life and occupational health. In the paper author suggested that the employer should evaluate the aspects of new developments that will affect occupational health and safety, also he should follow the software changes made to machinery and equipment. Workers using these systems should also receive the necessary training [16]. In Industry 4.0 workers need to be open to many different new and special skills. Conventional production knowledge and habits need to be combined with software skills. These can be difficult for employees who are used to the current working order. Employees' motivation to new production systems and open to learning will be beneficial for them. They need to be more flexible and accept continuing education to collaborate more effectively. The most important issue that employers will encounter in this regard is the training of existing employees and the recruitment of new employees who are equipped to learn better.

VI. CONCLUSIONS

Technological developments have changed the content and diversity of problems in the OHS field. Technology plays a very important role at the point where industrial revolutions have come. Many new technologies such as Internet-enabled production tools, decision-making machines, robots, digital databases will support traditional production tools and will take their place over time. Expectations from employees will also change in the transition to Industry 4.0. However, this situation will also affect the social lives of the employees and cause new risks to emerge. Occupational health and safety measures to be taken by experts should be adapted to new standards and legislation should be updated to cover these issues.

The components forming the core of the Industry 4.0 philosophy have been introduced and examples of good practices in the field of OHS have been examined in this paper. The aim of the present paper was to make the impact of Industry 4.0 on Occupational Health and

Safety more definable within a conceptual framework. The effects of Industry 4.0-based applications on OHS can be examined in more detail by comparing the before and after activities in future studies.

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