Impact of Industry 4.0 on robotic welding

To cite this article: A Farkas 2018 IOP Conf. Ser.: Mater. Sci. Eng. 448 012034

View the article online for updates and enhancements.

You may also like
- Industry 4.0: Eyinig The Future via Simulation
  Aisyah Ibrahim, Tuty Asmawaty Abdul Kadir and Adzhar Kamaludin
- Review: Identification of roadmap of fourth construction industrial revolution
  S E N Lau, R Zakaria, E Aminudin et al.
- Formation principles of digital twins of Cyber-Physical Systems in the smart factories of Industry 4.0
  A V Gurjanov, D A Zakoldaev, A V Shukalov et al.
Impact of Industry 4.0 on robotic welding

A Farkas\textsuperscript{1,2}
\textsuperscript{1} Flexman Robotics Kft.
\textsuperscript{2} John von Neumann University, GAMF Faculty of Engineering and Computer Science

Abstract. In our compilation we have a look at what is meant by the notion 'Industry 4.0' and how we can place it in the history of technical progress. The article reviews the general characteristics of Industry 4.0 and it also mentions the expected benefits of its introduction, as well as the challenges and risks entailed by it. We present how the technical- technological elements of Industry 4.0 appear in robotisation of welding, in addition, we examine the Hungarian experiments concerning this.

1. Introduction
The term Industry 4.0 indicates that industry has globally moved to the fourth level of progress, which is often referred to as the fourth industrial revolution. Despite the fact that nowadays Industry 4.0 is discussed by many and even conferences are organized on this topic, experience has shown that not all people know what it means exactly. A lot of people expect a lot of results from this era of industrial progress: some experts prognosticate 30 \% increase as a result of the technical-technological improvements of Industry 4.0. [1] It can be said that it is almost impossible to avoid this topic with regard to the robotisation of welding as well. But first of all, let us summarize what is meant by Industry 4.0.

2. About Industry 4.0 in general
Today manufacturing industry still has a significant impact on economy in the European Union, nevertheless compared to the EU’s economy as a whole, the proportion of manufacturing industry has been decreasing in the last few decades. This is partly resulted from the relocation of production in part to countries outside the EU – mostly to China. EU leaders expect the situation to be changed by the overall transformation of industrial production that we can observe today, and the main characteristics of which is the fusion of traditional industry, digitalisation and the Internet. have the same style to the title page. This paragraph follows a section title so it should not be indented.

2.1. Where does the term Industry 4.0 originate from?
The term originates from Germany: first it was used as a name for a digital manufacturing project at the Hannover Messe in 2011. [2] At that time the participants of the project may not have thought that, a few years later, this would become such a wide-spread concept.

2.2. Defining the notion Industry 4.0
Industry 4.0 is used to indicate the present phase of technical progress, which has noticeably entered a new era mainly as a result of progress in information technology. We have not found a uniform definition yet; each field of expertise approaches and tries to define the term in different ways. At all events, together with progress, apparently the definition of Industry 4.0 itself also goes beyond its limits defined...
earlier, which at the beginning was only applied to the so called digital manufacturing. It can help if we place the mentioned era on the historical timeline of technical progress, which we review in Table 1. [3]

### Table 1. Industrial revolutions

| Industrial revolution | Time periods | Technology and capabilities |
|-----------------------|--------------|-----------------------------|
| First                 | 1784-mid 19th century | Water- and steam-powered mechanical manufacturing |
| Second                | Late 19th century -1970s | Electric-powered mass production based on the division of labour (assembly line) |
| Third                 | 1970s-Today | Electronics and information technology drives new levels of automation of complex tasks |
| Fourth                | Today | Sensor technology, interconnectivity and data analysis allow mass customisation, integration of value chains and greater efficiency |

Naturally, transition from the earlier time periods to the fourth one did not happen suddenly; for example, since the second half of the third period the progress of artificial intelligence (which is an integral part of the fourth period) has been largely contributing to, and it has even laid the foundations for entering the next era called the fourth industrial revolution.

Therefore, at the moment there is no such thing as a uniform definition based on unanimous consensus. Also, it is difficult to provide a definition as Industry 4.0 has become more complex, and its effect goes beyond the establishment of smart manufacturing, which is evidently included in it:

- The transformation of manufacturing industry exceeds the field of manufacturing itself; it is not limited to its earlier goal, the establishment of ‘smart factory’,
- Industry 4.0 is more than automation and data exchange in manufacturing technologies because it goes beyond manufacturing and it is oriented toward the chain between the end points; for example, it includes storage, logistics, recycling, energy systems, etc.
- Cyber-physical systems, which play a central role in Industry 4.0, as well as intelligent networks, intelligent logistics and even intelligent buildings promote the establishment of smart factories operating in the smart manufacturing of smart industry.

I-Scoop collected seven definitions, from which I would like to highlight the following statements:

- Most of these evaluate this era as a completely new step, which they identify assess as the fourth industrial revolution indicated in Table 1.
- A significant increase in productivity ca be expected as a result of the convergence, interconnection of the technical-technological improvements that are characteristic of Industry 4.0, in which the Internet, digitalisation, artificial intelligence, advanced data management and data analysis play an important role.

2.3. The technical-technological pillars of Industry 4.0

The expected increase and improvement of Industry 4.0 in manufacturing is based on 9 pillars: [4], [5]

1. **Autonomous robots** – autonomous, cooperative robots, high-end sensors, intelligent operation, standardized interfaces
2. **Additive manufacturing** – 3D printing, especially for producing prototypes and individual components, decentralized options: less transportation and stock

3. **Augmented reality** – for maintenance, logistics, various standardized operation processes, display, with additional information e.g. by using special glasses

4. **Simulation** – simulation of value networks, optimisation of real-time data originated from intelligent systems

5. **Horizontal and vertical system integration** – complete enterprise data-integration based on data transfer standards, preconditions for establishing a fully automated value chain (from the supplier to the customer, from management to the workshop)

6. **The industrial Internet of things** – the network of machines and products, multidirectional communication between the network members

7. **Cloud-based systems** – the management of large amount of data in open systems, real-time communication between manufacturing systems

8. **Cybersecurity** – operation in networks and open systems, organizing intelligent machines, products and system into a network

9. **Big Data and analytics** – the full evaluation of available data (e.g. from ERP\(^1\), SCM\(^2\), MES\(^3\), CRM\(^4\) and from data of machines), the support of real-time decision making and optimization\(^5\)

In order to supplement the industrial Internet of things at point 6, we note that this one includes the cyber-physical systems, such as systems built from the building blocks – the so called IoT (Internet of Things) – of Industry 4.0.\(^6\)

IoT devices are devices connected to the Internet with specific IP address; one of their functions is the capability of uploading data and information autonomously to the Internet\(^7\), and in addition, it could allow distant interference via the Internet. [8]

Each component of the 9 pillars mentioned at the beginning of chapter 9 is already being applied separately in several areas (e.g. robotics, additive manufacturing etc.); however, we will only experience the advantages characteristic of Industry 4.0 when the convergence, the interconnected operation of all pillars will be achieved.

2.4. **The change in the role of human resources in Industry 4.0**

The introduction of Industry 4.0 also means a change in the tasks of professionals and in the requirements for them. At workplaces built on cyber-physical systems one has to find his way, make decision and interfere in more complex, more complicated systems. As opposed to the CIM manufacturing concept of the 80s, Industry 4.0 did not set the exile of human beings from production as an objective; instead, it aims to integrate humans into the structure of cyber-physical systems, which utilizes human experiences and skills. In order to achieve this, advanced HMI\(^8\) devices that are capable of conforming to the operation of cyber-physical systems need to be invented. Typically, these are mobile devices with touchscreen, which are made according to industrial design, have indoor positioning systems and apply virtual and augmented reality devices. [9]

---

1 ERP (Enterprise Resource Planning)
2 SCM (Supply Chain Management)
3 MES (Manufacture Executive System)
4 CRM (Customer Relationship Management)
5 It presents a solution provided for the purpose of e.g. service and maintenance [6].
6 We note that the literature also distinguishes the industrial version of IoT: its abbreviation is IIoT (Industrial Internet of Things). More details under [7].
7 A significant part of the huge amount of information available on the Internet has been uploaded/ is being uploaded by IoT devices.
8 HMI: Human-Machine-Interface – means of communication between the operator and the appliance
2.5. The expected benefits of Industry 4.0

Benefits expected from the application of options provided by Industry 4.0 are the followings: [5]

- **Growth of productivity**: due to the higher level of manufacturing’s automation, which reduces manufacturing time as a result of better utilization of assets and more efficient stockpile management
- **Improvement of flexibility**: mainly thanks to robotics, with the option of manufacturing wide range of products and variation of products.
- **Quality improvement**: with real-time, quick interference in case of errors with the help of advanced sensor technology and artificial intelligence
- **Improvement in speed**: the lead time between plans and their realization is reduced e.g. thanks to the advanced simulation devices and solutions efficiently fulfilling the customer’s needs. [10]

Additional co-benefits:
- Improvement of safety at work as a result of higher level of automation
- Improvement of working conditions with a workplace designed more ergonomically
- More efficient education and cooperation as a consequence of consistent data available in the manufacturing network
- Higher level of environmental protection by utilising resources more efficiently e.g. by operating machines at a higher efficiency level while saving energy.

2.6. Challenges and risks of applying Industry 4.0

Besides the expected benefits, the introduction of Industry 4.0 also offers challenges for professionals; moreover, certain risks should be considered as well. [5]

In terms of challenges, first we have to consider the followings: determining the adequate strategy, rethinking organization and processes, changing the management, the effect of the company’s culture, developing an efficient cooperation between different departments and a solution for supporting talents.

The introduction of Industry 4.0 will polarize the companies: based on the forecasts, those who apply it correctly (or those who apply it at all) will gain a considerable advantage compared to those who do not want or cannot move to this direction.

In terms of risks, experts primarily draw our attention to the fact that the IoT devices, such as interfaces between the cyberspace and physical world, used in Industry 4.0 mean a potential safety threat regarding cyber attacks; [11] also, they are capable of amplifying their effects by directly interfering in the physical world. [12] Therefore, information security is key in Industry 4.0. Information security can be interpreted in two ways; in both cases we need to find solutions in order to secure a reliable system operation and to provide protection against external, illegal intrusion and interference. [13]

3. Applying Industry 4.0 in the robotisation of welding

When studying the field of welding, today it is too early to talk about the successful introduction of complex Industry 4.0 solutions; nevertheless, regarding the technical-technological solutions listed in chapter 2.3 progress has been made in some areas of the robotisation of welding.

One of the main pathways of development aimed at Industry 4.0 is the **robotisation of welding** itself; this is how developments that focus on this area and are firmly present in robotisation can get into the field of welding. Some examples for this: developments in sensor technology, application of artificial intelligence, [14] the development of standardized robot interfaces, interface for open source programming, remote diagnosis via the Internet, maintenances, intelligent forecast of the need for part
In the last few years, in the robotisation of welding we have observed a rapid development in the options of programming technology. With the help of these, the boundaries of the economical application of welding robots can be extended to smaller series and even to individual production. One option for this is simplifying the traditional direct on-line teaching, which would provide settings for the robot’s welding torch through manual movement. This method can make the teaching process of relatively short and simple welding programmes more efficient in smaller robot cells, as the programmer does not need to think in co-ordinate systems when moving the robot manually.

Bigger and more complex programmes can be efficiently made with off-line programming software so that the robot does not have to be withdrawn from production during most of the programming time. The data of robot cells connected to local networks can be remotely accessed and easily supervised. Welding process archiving systems, applied as part of quality management, are capable of storing huge amount of data, which can be efficiently processed by Big Data systems. Also, the field of additive manufacturing, mentioned in chapter 2.2 in relation to Industry 4.0, is primarily present in welding when robotisation takes place. In this respect we can give account of a Hungarian development as well.

The latest developments of welding equipment have also largely contributed to the improvements of the robotisation of welding. In this respect we can mention the solutions of the industrial Internet of things and the cloud-based systems for data transfer, which allows data transfer e.g. between welding machines (M2M – Machine to Machine). These solutions are suitable for e.g. identifying the welder, indicating the decrease in welding material, the remote observation of different status information, even from a smart phone. Therefore, these characteristics of welding equipment are not only available for robotic welding but for manual equipment as well.

- 11 point Times or Times New Roman.
- The text should be set to single line spacing.
- Paragraphs should be justified.
- The first paragraph after a section or subsection heading should not be indented; subsequent paragraphs should be indented by 5 mm.

4. Hungarian experiences
In order to get a realistic picture of this topic, we have collected information from welding technology trading companies, and primarily from the official Hungarian distributors of welding equipment manufacturers [19].

Essentially, developments characteristic of Industry 4.0 can be discovered at every national welding machine distributing company, which manufacture appliances suitable for robotisation, although to different degrees, in different areas and with different complexity.

In the first place this development process started with the improvement of communicational skills, remote diagnosis and options for process archiving and remote access. M2M communication, Big Data-based statistical methods are already applied and, in some cases, efforts to use cloud-based communicational solutions can be observed as well.

In Hungary there are great differences between users’ demands that can be related to Industry 4.0. There are territories where everyday problems (usually caused by the chronic lack of labour force) distract people’s attention from such developments. There are places where the introduction of “Industry 3.0’s” developments could be the next step; at the same time, appliances integrating the newly available developments automatically include certain components of Industry 4.0, especially in the field of mechanization/automation. In this way solutions related to Industry 4.0 automatically become a part of the companies’ lives.
As car industry is a significant field of use for welding in Hungary, solutions characteristic of Industry 4.0 and related demands “arrive” from Western Europe together with this industry. At the same time, we have to note that certain developments – such as process supervision and data collecting/archiving that operate through networks – were already present as available solutions before Industry 4.0. These provided good basis for the next steps: introducing solutions now related to Industry 4.0.

**Summary**

Industry 4.0 stands for the fourth phase of industrial development, in which mainly digitalization and Internet solutions play a dominant role. Having reviewed the main fields of Industry 4.0 we concluded that nowadays, with regard to the robotisation of welding, we can observe such integral parts as advanced solutions in robotics, artificial intelligence, the additive manufacturing and cloud-based solutions. By all means, these are progressive solutions; still, according to the experts’ prognosis, we will be able to really benefit from Industry 4.0 when these partial solutions are interconnected in almost every area and operate efficiently together. Having examined the Hungarian situation, we can say that solutions characteristic of the developments of Industry 4.0 are already available in our country. We are still in the introductory phase, which means that on the suppliers’ side developments and certain employable solutions characteristic of Industry 4.0 are present, but related demand on the users’ side still varies greatly.

**References**

[1] Otte C: What is Industry 4.0? BDI Internet: [https://english.bdi.eu/article/news/what-is-industry-40/](https://english.bdi.eu/article/news/what-is-industry-40/) 2018.03.15

[2] i-Scoop: Industry 4.0: the fourth industrial revolution – guide to Industrie 4.0 [https://www.i-scoop.eu/industry-4-0/](https://www.i-scoop.eu/industry-4-0/) 2018.03.16.

[3] Briefing September 2015 - European Parliament: Industry 4.0 - Digitalisation for productivity and growth Internet: [http://www.europarl.europa.eu/RegData/etudes/BRIE/2015/568337/EPRS_BRI(2015)568337_EN.pdf](http://www.europarl.europa.eu/RegData/etudes/BRIE/2015/568337/EPRS_BRI(2015)568337_EN.pdf) 2018.03.16.

[4] Rüssmann M and co-autors: Industry 4.0: The Future of Productivity and Growth in Manufacturing Industries 2015. aprilis 9. Internet: [http://www.inovasyon.org/pdf/bcg_perspectives_Industry_4.0_2015.pdf](http://www.inovasyon.org/pdf/bcg_perspectives_Industry_4.0_2015.pdf) 2018.03.25

[5] BCG: Sprinting to Value in Industry 4.0. Internet: [https://translate.googleusercontent.com/translate_c?depth=1&hl=hu&prev=search&rurl=translate.google.hu&sl=en&sp=nmt4&u=https://www.slideshare.net/TheBostonConsultingGroup/sprinting-to-value-in-industry-40&usg=ALkJrhjpmzQbNJOI42v0hYnkLkL_cSZuA](https://translate.googleusercontent.com/translate_c?depth=1&hl=hu&prev=search&rurl=translate.google.hu&sl=en&sp=nmt4&u=https://www.slideshare.net/TheBostonConsultingGroup/sprinting-to-value-in-industry-40&usg=ALkJrhjpmzQbNJOI42v0hYnkLkL_cSZuA) 2018.03.21.

[6] Lee J, Kao H-A, Yang S: Service innovation and smart analytics for Industry 4.0 and big data environment. ScienceDirect, Procedia CIRP 16 (2014) pp. 3-8.

[7] i-scoop: The Industrial Internet of Things (IIoT): the business guide to Industrial IoT Internet: [https://www.i-scoop.eu/internet-of-things-guide/industrial-internet-things-iiot-saving-costs-innovation/](https://www.i-scoop.eu/internet-of-things-guide/industrial-internet-things-iiot-saving-costs-innovation/) 2018/03.21.

[8] Farkas B.: IoT alapú motorvezérlés. Szakdolgozat, 2017. BME Villamosmérnöki és Informatikai Kar, Villamos Energetika Tanszék pp. 9-14.

[9] Gorecky D, Schmitt M, Loskyl M, Zühlke D: Human-Machine-Interaction in the Industry 4.0 Era. Innovative Factory Systems, German Research Center for Artificial Intelligence (DFKI), Kaiserslautern, Germany 2014 12th IEEE International Conference on Industrial Informatics (INDIN) Porto Alegre, Brazil pp. 289 – 294.
[10] Zawadzki P, Zywicki Z: Smart Product Design and Production Control for Effective Mass Customization in the Industry 4.0 Concept. Management and production Engineering Review. Volume 7, number 3 September 2016. pp. 105-112
[11] i-scoop: IoT security: smart business requires smarter Internet of Things security. Internet: https://www.i-scoop.eu/iot-security-smarter-internet-of-things-security/ 2018.03.21.
[12] Schneier B: The Internet of Things Will Turn Large-Scale Hacks into Real World Disasters. Internet: https://motherboard.vice.com/en_us/article/qkjzwp/the-internet-of-things-will-cause-the-first-ever-large-scale-internet-disaster 2018.03.21.
[13] Seacon Europe: Ipar 4.0 Internet: http://www.industry4.hu/hu/ipar4 2018.03.15
[14] Farkas A: A mesterséges intelligencia szerepe a hegesztés robotosításában. 26. Hegesztési Konferencia, Budapest, 2012. Május 10-12. ISBN: 978-615-5018-28-2 pp. 45-51.
[15] Garcia L A: Robot systems at YASKAWA: today and tomorrow 2018.02.26. Internet: https://www.yaskawa.eu.com/en/news-events/news/article/news/robot-systems-at-yaskawa-today-and-tomorrow-1/?tx_news_pi1%5Bcontroller%5D=News&tx_news_pi1%5Baction%5D=detail&cHash=4a98525248e3d1998a86f8ab23ea3681 2018.03.22.
[16] Yaskawa: Kinetiq teaching - Expanding robotics for agile manufacturing https://www.motoman.com/hubfs/Images/Kinetiq_Teaching.pdf?t=1480625354642 2018.05.29.
[17] Uzonyi S, Asztalos L, Farkas A, Dobrânszky J: Az additív gyártás jelen és jövője. Hegesztésteknikai 28/3 (2017.) pp. 89-92.
[18] Uzonyi S, Asztalos L.: Additív gyártás robotosított, huzalelektródás, védőgázos hegesztéssel. 28. Hegesztési konferencia Dunahéváros, 2016. május 26-28.
[19] Farkas A, Palotás B: Az Ipar 4.0 hatása a hegesztés szakterületére. 29. Nemzetközi Hegesztési konferencia, Miskolc, 2018. május 24-26. pp 11-25.