

# Structural Network for the Implementation of "Industry 4.0" in Production Processes

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**Abstract:** In the last ten years, the development and implementation of robotics, sensor and digital technology in the world from introduced us the third industrial revolution to the fourth industrial revolution. In its development strategy, Germany introduces digital technologies in production processes called "Industry 4.0" in 2011. The German example is followed by the following countries: USA, Great Britain, Sweden, Japan and other. Almost all technologically developed countries strive to introduce advanced technologies into production processes in order to maintain their competitive positions in the market. The implementation of the fourth technological revolution depends on a number of new and innovative technological achievements, i.e., the implementation of patents for the basic technologies of Industry 4.0. It is necessary to integrate production processes in all phases of product development, as well as monitoring during its working life through the use of advanced technologies. When automating production processes, we must include intelligent sensors, intelligent robots and connect everything to the Internet using digital technologies that closely monitor the product development process. It is also required to collect large amounts of data through network communication used during the production process. The paper presents a structural network with all levels for the implementation of Industry 4.0 in the production process of the metal industry.

**Key words:** Industry 4.0, robot, smart sensor, digital technology, production process, smart automation.

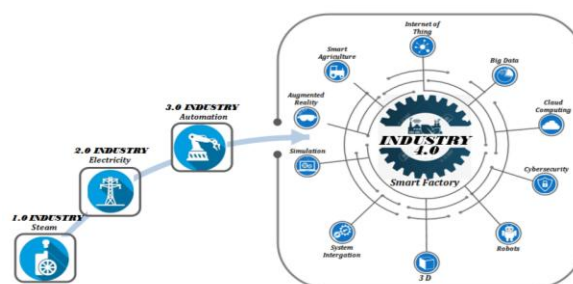
## 1. Introduction

In the last 20 years, there has been a development of digital technologies that are implemented in the production processes themselves. We are at the beginning of the fourth industrial revolution because many industrial development strategies of countries in the world that are considered technologically advanced advocate the transformation of industrial production through the implementation of all advanced technologies, especially digital technologies. Germany first announced part of its High-Tech Strategy 2020 program in Hanover in 2011 under the title "Industry 4.0", while in the USA, in 2012 the Advanced Manufacturing Partnership Steering Committee provided recommendations for positioning the USA for long-term leadership in advanced technology. Similarly, in 2013, the UK Government Office for Science highlighted the strategy under the title "The Future of Manufacturing - A New Era of Opportunity and Challenge for the UK", while China under the title "Made in China 2025" wants to become the most technologically advanced country in the world; The Government of Japan presented its strategy under the name "Robot Revolution" [1, 12-14, 20-21], and the Swedish Government's strategy for new industrialization is to strengthen the capacity of companies for change and competitiveness through automation and digitalization. Industry 4.0 is creating radically new approaches that will involve individuals and institutions in a revolutionary way. The Industry 4.0 platform aims to match supply and demand in a very affordable way by providing the customer with a wide range of products without both parties interacting. The inclusion of digital technologies with other advanced technologies will transform the production processes in industrial production due to the fact that the price of this technology is constantly declining in the market and are increasingly widespread in production processes, and the second reason is that ICT technologies are implemented with other technologies and enable digital transformation of production processes [1-2, 7, 9, 16-19, 24-32]. When it comes to the transformation of production processes, it is impossible to imagine without the inclusion of robotics,

digital and sensor technology. The second generation of industrial robots has been developed, and new generations of robots must be intelligent and autonomous, thus increasing the reliability of the production process, as well as reducing the time to produce the finished product, as well as precision and adaptability beyond human capabilities.

## 2. The implementation of patents in technologies that are the basis for Industry 4.0 expands the application of Industry 4.0

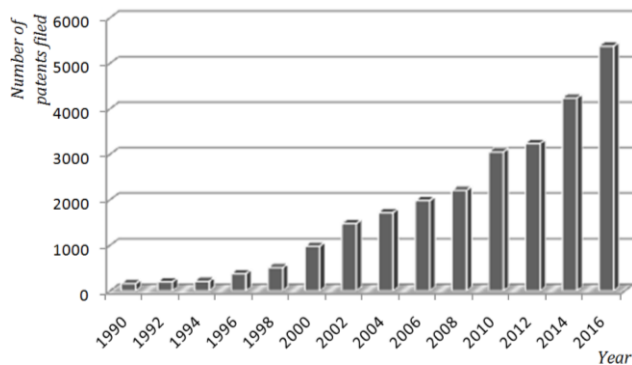
To date, we have had three industrial revolutions in the world: the invention of the steam engine was marked as the first industrial revolution, and the invention of electricity as the second industrial revolution. The rapid development of informatics and automation electronics was marked as the third industrial revolution, while the world today is on the brink of the fourth technological revolution "Industry 4.0" as shown in Fig. 1.



**Fig. 1.** Industrial revolutions in the world and their evaluation

Industry 4.0 is a digital transformation of production/related industries and the process of creating new value [3-5, 22-23, 28, 30-32]. Digital transformation must be integral, comprehensive, involving all actors in global politics, from the public and private sectors to civil society and academic community [6, 29]. Within the fourth industrial revolution, a new value chain is being formed that relies primarily on Cyber-Physical Systems

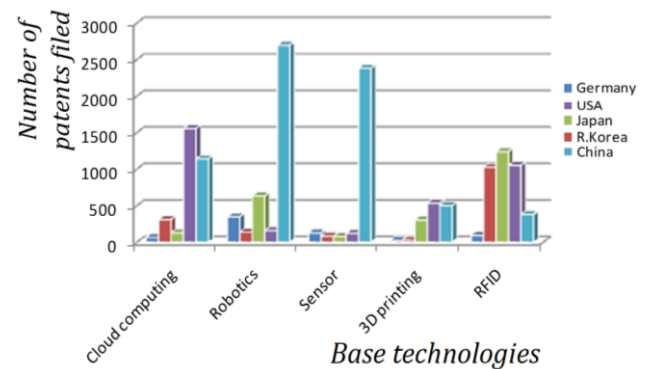
(CPS) which is also another name for the Internet of Things (Internet of Things), and its associated service most often implemented in the cloud (Cloud Computing). The implementation of Industry 4.0 is taking place through the massive use of the Internet of Things (IoT). Some studies estimate that by 2025, there will be 26.30 billion devices in homes equipped with sensors, processors and embedded software and connected to the Internet of Things (IoT). Numerous patents are responsible for this trend of implementation of basic technologies from Industry 4.0, as shown in Fig. 2 [25], which shows the trend of applying for patents of the fourth industrial revolution - Industry 4.0, which were applied to the EPO's free database "European Patent Office (EPO)" in the European Union until 2016.



**Fig. 2.** Number of filed patents of the fourth industrial revolution - Industry 4.0 in the European Union [25]

By analysing Fig. 2, we come to the conclusion that we have a continuous growth of patents from the basic technologies of the fourth industrial revolution in the European Union. From 1990 to 2016, it can be roughly concluded that the trend of patent filing and applications follows an exponential function, so that in 2016 the number of patents reached 5.380. We see that the latest available data on filed patents signal the implementation of Industry 4.0. In order to create an image of which countries in the world and which are the base technologies of Industry 4.0 where the largest number of patents filed, we need to do analyse Fig. 3 [8]. By analysing Fig. 3 we come to the conclusion that in the first place in the world is robotic technology in terms of reported and implemented innovations, where China is in first place, Japan in second place. In second place is RFID technology, then in third place is cloud computing, in fourth place are smart sensors and the last fifth technology 3D printing by reported and implemented innovations.

The trend of applying Industry 4.0 innovations allows only limited conclusions about patents and their implementation, as there are a huge number of low-quality patents from Industry 4.0 in China. The second reason why this trend of innovation in China should be taken with a grain of salt is the dysfunctional government policy that rewards the registration of innovations regardless of their quality and the third reason is that many reporting innovations from China's industry seem lower quality their acceptance rate is significantly lower.

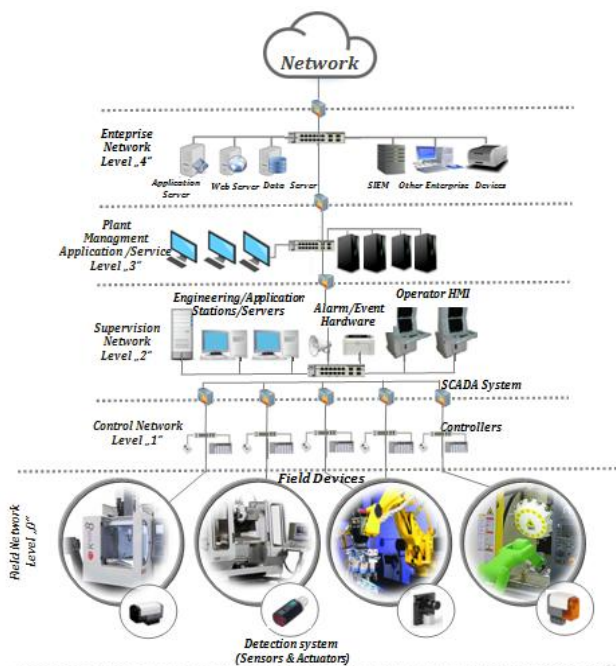


**Fig. 3.** Trend of patent applications from the five basic technologies of Industry 4.0 in technologically developed countries [8]

### 3. Structural Network for the Implementation of Industry 4.0 in Industrial Production Processes of the Metal Industry

For the implementation of "Industry 4.0", regardless of the principles on which the scenario is based, it is necessary that the application of innovation, software and hardware structure comes first. After that, in second place is the education of users - consumers, i.e., training programs for the general population. In order to implement Industry 4.0 in third place it is necessary to integrate with new technologies that we have listed as shown in Figure 4. It is necessary to enable CPS to monitor industrial production processes, connect data obtained through implemented sensors in production processes with virtual and simulation production models, in other words, create a virtual copy of the physical production process. The development and implementation of powerful computers enables the CPS to make its own decisions within the production process of the "smart factory", in other words, decentralization is performed, there is no need for central planning and supervision. In order to implement all of the above, it is inconvenient to establish an Industry 4.0 value chain, which means between new technologies such as IoT, ICT, CPS, .... etc., with consumers, devices and tools. Many research institutions around the world are working on the development and implementation of various "Industry 4.0" implementation scenarios. In Germany prof. M. Herman and his colleagues identify project principles such as: interoperability, decentralization, virtualization, real-time capability, service orientation and modularity, on which the Industry 4.0 implementation scenarios are based. Until recently, we had a traditional linear supply chain, but today many product supply chains are being transformed from a static array into a dynamic array that is evolving to an optimal state. Development and Implementation of Industry 4.0 in the production processes of the industry - Smart factory is characterized by the following most important characteristics: *connectivity, optimization, transparency, proactivity and agile flexibility*. The connectivity of the production process is one of the most important characteristics. By implementing a large number of smart sensors that provide continuous data sets, ensure that data is constantly updated and provide current operating conditions, and the integration of data from operating and business systems, as well as suppliers and customers allows us to view the input and output supply chain processes and in this way we are

able to increase the overall quality of the supply network itself with our products. Another feature is the optimized production process that allows us high reliability, optimization of energy input from the input, production and output chain, minimal manual intervention, automation during the production process, reducing costs and waste, etc. The data captured by smart sensors is transparent, allowing greater visibility throughout the production chain, allowing the organization to make the right decision or make autonomous decisions through analysis provided by tools such as real-time displays, alerts and notifications. The production process becomes a proactive process where employees and systems are able to anticipate and act on time before a problem arises. This feature includes the identification of anomalies, by having the ability to predictively solve the problem of quality in the production process of the product, as well as monitoring safety and maintenance. The agile flexibility itself enables the production process to adapt to the schedule and changes of the product with minimal intervention. Industry 4.0 implementation allows independent configuration of equipment and material flows depending on the product being produced and scheduled changes that we can monitor in real time, and the structural network of Industry 4.0 implementation in the metal industry production process is shown in Fig. 4. [10, 12, 14, 18].



**Fig. 4.** Structural network scheme with all levels for the implementation of Industry 4.0 in the production process of the metal industry [10, 12, 14, 18]

Fig. 4 shows us that the structural implementation network of Industry 4.0 in any production, including the textile industry, consists of five levels. Zero level is a network of production processes of the textile industry where sensors are installed to monitor production processes and to detect systems. After the zero level comes level 1, i.e., the control network, where we can use controllers to act to eliminate errors that occur in the production process. The third level is the supervision network that monitors everything, and gives a signal/alarm

if something is wrong. In the third new is the operations management network, and in the last level 4 is the company network that is connected to all possible information via the cloud as shown in Figure 4. Industry 4.0 not only serves large companies; currently small companies can compete with large companies on a way they had never been able to before.

#### 4. Conclusion

We can conclude that new technologies include: IoT (Internet of Things), robotics, cloud computing, smart sensors, radio frequency identification, cyber-physical systems and big data, are key in the application of the Industry 4.0 concept, in all industries, and the same so in the metal industry as shown by the structural network with all levels for the implementation of Industry 4.0, because it implies complete digitalization of all production processes, also when creating an idea about a product, product engineering, production organization, process control and industrial services. There is a continuous increase in the application of Industry 4.0 in the world, and this is confirmed by the trend of applying for patents from Industry 4.0 from basic technologies: Cloud Computing, Robotics, Sensor, 3D printing, RFID, both in the European Union and in the world. With the application of Industry 4.0 in production processes, the company has advantages such as: increasing efficiency, increasing the speed of production, increasing product quality, increasing flexibility, increasing operational safety. In addition, with the implementation of Industry 4.0, the company expands its access to the global economic market because it has a wide user base. There are three challenges when it comes to the Industry 4.0 application in the company. The first challenge relates to methods and methodology, especially how to integrate machines and devices within the production process. The second challenge is education, i.e., how to prepare new generations of engineers who need to work and implement Industry 4.0. The third challenge is about society, primarily how to explain to people that Industry 4.0 creates new opportunities and brings a better quality of life for all of us, without having to be afraid of change and everything that Industry 4.0 brings. Great attention in the world is paid to Industry 4.0 and the role of man in integrated factories, which are getting closer to realization day by day.

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