PROCESSES OF INNOVATIONS IMPLEMENTATION INTO INDUSTRY 4.0. AUTOMOTIVE INDUSTRY STANDARDS

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Abstract
Industry 4.0 is a designation for the automation of production and labour market changes that this will bring. It is based on the boom of digitization, robotization and automation. The Industry 4.0 concept brings the benefits of increasing productivity, reducing costs and making mistakes they result from the involvement of more sophisticated machines in all company processes. The aim of this article is to present the ongoing fourth Industrial revolution (Industry 4.0.) and the impact of innovations in the company. Implementation of innovations are presented, innovation cycle itself and innovations effect on companies. Industry 4.0 makes full use of emerging technologies and rapid development of machines and tools to cope with global challenges in order to improve industry levels. Also, concepts of innovation and digitization are currently a central task for future competitiveness. Therefore, companies are establishing brand new departments focused on innovations in Industry 4.0. Industry 4.0 and digital transformation bring new opportunities in the areas of customer search, improving product offerings, and new opportunities for creating and delivering value, thus opening up new ways to create profit. First part theoretically describes various approaches to this problematic, description of four industrial revolutions and Industry 4.0. itself. Next implementation of innovations is presented, innovation cycle itself and innovations effect on companies. The last part of the article covers innovations in context of Industry 4.0. (both methods and technology) within the automotive industry. Main impact of the work is that this article puts in correlation both importance of the ongoing fourth industrial revolution with innovations in the company. It is very interesting, that these innovations with modern technologies help companies to operate more effectively.

Keywords
innovations, industry 4.0., implementation, company, production

Introduction

Technological progress has gradually created the idea of the fourth Industrial Revolution, which combines a number of key technologies and allows realizing the production in which individual machines and products communicate with each other. In modern history, every industrial revolution was characterized by the onset key industrial technologies. The first industrial revolution by invention water and steam propulsion, which revolutionized manufactory production. Second revolution then introduced electricity into production, households, and the public sector, and first serial production line. So far, the last, third industrial revolution is linked to the deployment and use of computer and robotic technology in virtually everyone areas of human activity, including industrial production [1].

Now, two hundred years after the first industrial revolution, we are at the threshold of the Fourth Industrial Revolution. Here, digital technologies and significant innovations have started development. Many of them got into life very quickly - like smartphones and mobile apps, fast internet or data storage.

Industry 4.0 is a designation for the automation of production and labour market changes that this will bring [3]. Industry 4.0 is based on the boom of digitization, robotization and automation. Number 4 marks the fourth industrial revolution, which is characterized by the full intertwining of information technology and production processes, in an intelligent way that is characteristic of autonomous machines. It is therefore largely based on

the Internet of Things, which has brought a number of changes to manufacturing and maintenance in the industry - from reducing the production cycle to automating the maintenance of machinery and equipment [4].

In Czech Republic, Ministry of Industry and Trade deals with Industry 4.0 Initiative. According to [5] Industry 4/0/ and its impact are summarized to this definition: "Industry and the whole economy are currently undergoing a major change caused by the introduction of information technologies, cybernetic-physical systems and artificial intelligence systems into production, services and all economy. The impact of these changes is so crucial that they are referred to as on the 4th Industrial Revolution"

Although the fourth industrial revolution does not bring a completely new, revolutionary technology, we can talk about another epoch. The principle of Industry 4.0 is what make the most of current technology. Moreover, especially thanks communication of computer technology - hence machines and devices with each other. The result should be significantly modified production - the so-called high flexible mass production in a smart factory [6].

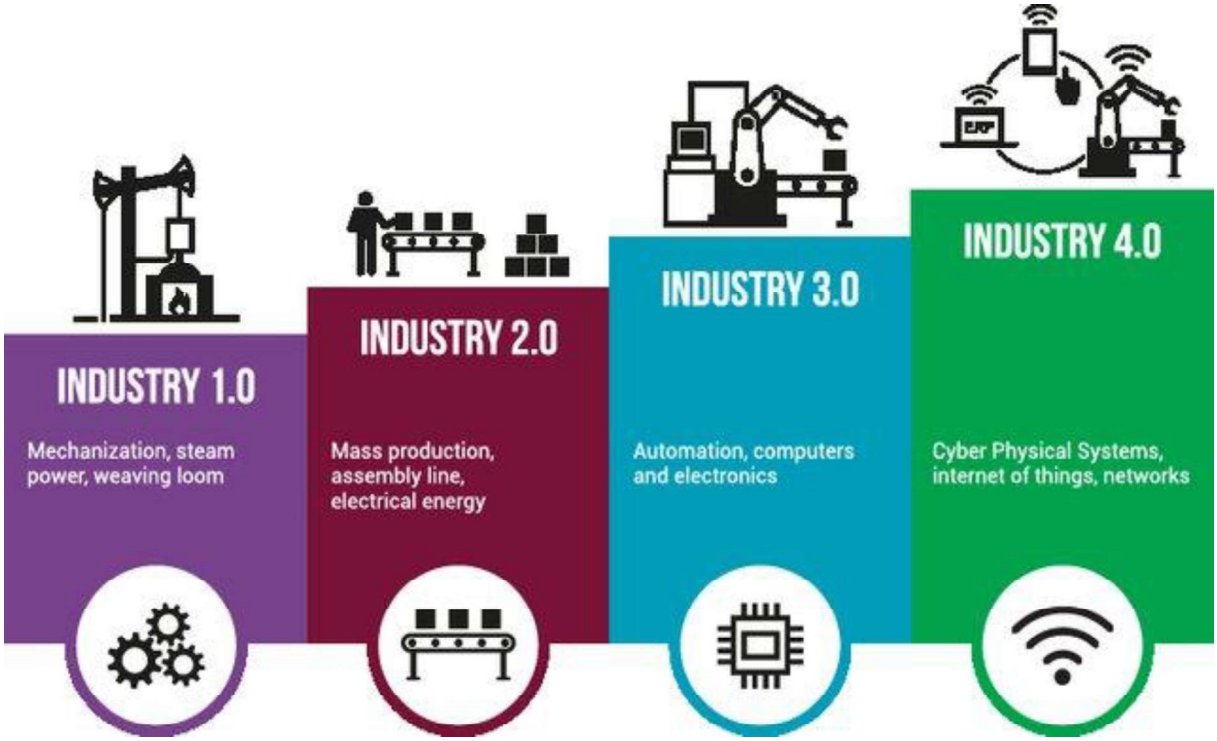

Fig. 6. Four industrial revolutions. *Source: [2]*

According to [7] Industry 4.0 makes full use of emerging technologies and rapid development of machines and tools to cope with global challenges in order to improve industry levels. The main concept of Industry 4.0 is to utilize the advanced information technology to deploy IoT services [8]. Production can run faster and smoothly with minimum downtime by integrating engineering knowledge. Therefore, the product built will be of better quality, production systems are more efficient, easier to maintain and achieve cost savings.

Gilchrist [9] in his book "Industry 4.0 The Industrial Internet of Things" highlights the 4 main characteristics of this revolution:

1. Vertical integration of intelligent manufacturing systems - that is creating networks of smart products, factories and other manufacturing systems is a necessity, because smart factories cannot work independently.
2. Horizontal integration through the global value chain of networks - probably the most important characteristic - it is the relationship between business partners and customers that should result in a global network.

3. Engineering technology across the entire value chain - the main goal is to create a product that fully meets customer expectations. This means that Industry 4.0 takes in and includes not only the production of the product, but its entire life cycle.
4. Acceleration of production - greater emphasis is not placed on technology, which is the product but to create a better value chain.

This is possible mainly due to the expansion of 'intelligent' technology, such as cars or industrial robots, wristwatches or lawn mowers, pacemakers or ultrasonic devices. All these interconnected devices and products have three key elements in common:

- physical components, i.e. mechanical and electronic components,
- "Intelligent" components, such as sensors, microprocessors, data memory, controls, software, integrated operating systems, or visual user interfaces,
- interconnection components, antennas, interfaces, protocols and networks [10].

The latter components enable communication between the product and the cloud, i.e. the external operating system of the product. Such state-of-the-art devices are part of platforms that allow continuous data exchange between the product and the user and link information that comes from the enterprise's system to those from external sources (e.g. spatial or weather, traffic) data. This allows the following six new functional properties to be defined.

Table 4. Functional properties of Industry 4.0. *Source: [11]*

Inspection	Interconnected devices and products can control their surroundings and their activities, providing information about their performance, functions and usage.
Remote control	Users can also solve complex tasks remotely through interconnections (e.g. in hazardous or hard to reach areas).
Optimization	The combination of control and remote control also enables optimization of the entire process chain - from purchase through production to shipping. This makes it possible to improve the performance, utilization rate and availability of interconnected systems, e.g. in production or farms.
Automation	The interoperability and interplay of data control, remote control and optimization allows for further automation - devices, machines and products can adapt to the environment and user preferences, self-maintain and operate independently.
Focus on services	If businesses have data on the sale and use of their products at any time, they can react very flexibly and, for example, instead of a one-off price increase, they can raise fees that are appropriate to the product's usage. Following the example of the software industry, where a rental model (Software as a Service, SaaS) has long existed and is commonly used, traditional technology companies are now using new product-based services ("product as a service").
Individualization of the product	Increasingly interconnected and intelligent manufacturing processes, as well as additive manufacturing and 3D printing, make it possible to produce products precisely to the customer's expectations. Today, almost all products can also be offered in small batches, starting from one piece, with the same price structures that were previously only available for larger orders and relatively standardized products.

The technology base of smart factories according to Industry 4.0 [12] is based on these design principles.

1. Interoperability - ability of individual components (cyberphysical systems, people, controllers of a smart factory as such) communicate with each other using Internet of Things
2. Virtualization - creating a virtual model of a smart factory using data linking obtained from sensors that monitor real processes, with imaginary models equipment and machines; physical models of the product are also replaced by virtual ones
3. Decentralization - individual cyberphysical systems within a smart factory are able to make their own decisions
4. Real-time operation - ability to communicate between devices and products and the immediate collection and analysis of data, enabling production facilities make independent decisions and also provide detailed information about everyone's progress processes
5. Service orientation - provision of services (cyberphysical systems, human or intelligent factories) via Internet services

6. Modularity - the flexibility of smart factories and their ability to adapt changing customer requirements by replacing or expanding individual modules.
7. Vertical and horizontal integration of production systems - vertical = information interconnection across all levels of the enterprise; horizontal = information links throughout the supply chain

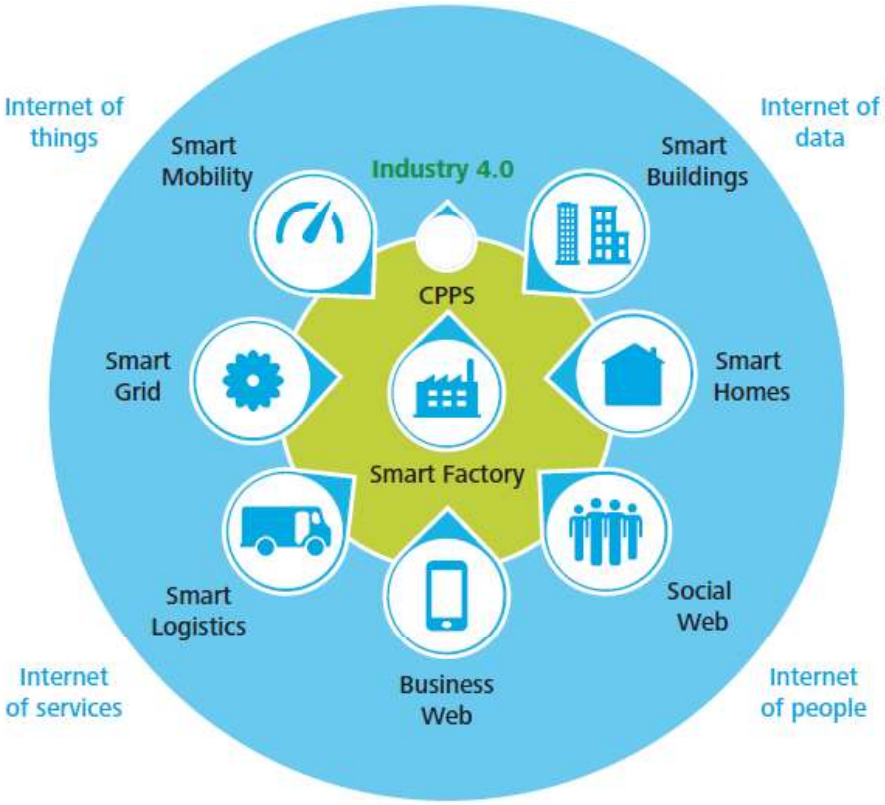

Fig. 7. The Industry 4.0. Environment. *Source: [13]*

Methods

In order to gain a better insight into implementation of innovations into Industry 4.0. company processes company innovations need to be defined. Various approaches based on latest research [2,8,12,14,15,23-25] are presented. Typology of innovations is important in order to clearly define the innovation processes.

Innovation can be the subject of any industry, it is easy to talk about, but it leads from words to actions long and demanding process [14]. Innovation can be described in a simple way as something the organization is working on at the time strives to meet one's needs. A number of authors devote to the definition of innovation and distinguish them with her gaze on her. There are definitions that are rather general but also definitions that are they focus more specifically on economics or sociology.

Invention is the name for a certain creative activity that leads to change [15]. These are mainly new ideas, ideas, and inventions. Those inventions that are realized and achieve commercial use are called innovations. Others serve only science and gain further knowledge, thoughts that lead nowhere. Inventions in the company thus represent a certain potential for creating new ideas. We distinguish between inventions absolute (brand new idea) and relative (new idea within the given organization or region). Put simply, "innovation is a realized invention".

Finding a generally valid definition of innovation is almost impossible there is no clear definition. However, from the origin of the word (innovare = from lat. refresh) it is clear that it will always be a change or novelty [16]. We can say that each author who deals with this topic creates his own definition for his own needs. The notion of innovation can be very subjective. Therefore, I would like to point out here a few with definitions of specific authors.

One of the first to address this topic was J. A. Schumpeter, whose theory is still considered the basis of a modern approach to innovation [17]. Schumpeter considered innovations only entirely new things, which are given by promoting new combinations. So, innovation based on absolute invention. Their purpose is primarily to fill the gaps in the market, which is based on his concept of an entrepreneur as a person seeking these market gaps. Schumpeter's followers already consider innovation not only absolute innovations in the world, but also relative changes within the company.
According to [18] innovation is similarly conceived to J.A. Schumpeter, especially in relation to the entrepreneur.

"Innovation is a specific tool for entrepreneurs, a means by which to use change as an opportunity for doing business in a different area or providing different services. They can be presented as a theoretical discipline that can be learned and practically used. Entrepreneurs must purposefully look for sources of innovation, that is, changes and their symptoms, which signal opportunities for successful innovation. And they must know and apply the principles of successful innovation."

From above mentioned, it is clear that the concepts of innovation and digitization are currently a central task for future competitiveness. Therefore, companies are establishing brand new departments focused on innovations in Industry 4.0., where topics such as enterprise-wide digitization, connectivity and new mobility solutions are the main pillars of the digital strategy. Innovations are a driving force and companies are taking advantage of the new opportunities made through digital transformations [19].

Typology of innovations

The most frequently used typology of innovations in terms of subject matter is classification according to the third version of the Oslo manual [20]. The difference from the previous version is the additional inclusion of the marketing and organizational innovation services sector. Originally, there were only technical innovations, i.e. product and process.

Table 5. Innovations typology according to Oslo manual. *Source: [20]*

Product innovations	• changes that are directly related to the product, • may include a whole new technique, may be based on a combination of existing techniques for a new application, or may be acquired through the application of new knowledge.
Process innovation	• change in the technological processes of production or in another arrangement of supply networks, • "may include changes in the facility or organization of production, or a combination of these changes, and may be obtained through the use of new knowledge", • brings positive results in reducing material consumption and labour costs, improving working conditions and the environment.
Marketing innovations	• "the introduction of a new marketing method containing significant changes in product or packaging design, product placement, product promotion or valuation", • goal of marketing innovations is to increase sales, • defined by a new marketing method that has never been used in an enterprise before.
Organizational innovation	• based on the use of new organizational methods in corporate business practices, job organization or external relations, • part of strategic decisions and the newly introduced methods in the business have never been applied before.

Innovation process

The innovation process can be understood as the path by which the innovation initiative creates a new product (or any other kind of innovation), which is further disseminated. It monitors individual phases of implementation and subsequent commercial use of innovation. The innovation process is a process that, according to Karel Skokan [21], ideally has three phases.

- Invention - is started by an idea for something new that is a concrete idea. It continues through the various phases of design, research and development. After verification of economic or market utilization, the invention leads to the adoption phase.

- Adoption - At this stage, the first commercial use of the idea takes place. In connection with this, certain organizational, financial and investment, activities in production and sales are required. This phase is completed only when the initial invention is actually received and utilized. The introduction of the invention to the market is varied, the innovation can be adopted immediately or it can take several years.
- Diffusion - represents the phase of the innovation process, when knowledge about invention is expanding. Innovation is spreading very unevenly due to resistance, e.g. in the form of information deficits. As a result, people get information in different places at different times.

Implementation of innovation into production cycle [22]

At the beginning of every thoughtful and promising innovation, an innovation analysis is needed opportunities. The innovation cycle consists of seven basic phases that are grouped into three stages.

1. Stage of strategic preparation of innovations
    a. Phase 1. Innovation forecasting - analysis of state and tendency of innovation, direction of innovation in the organization in the long run. The output is innovative ideas.
    b. Phase 2. Innovation concept - formulation of the main objectives through conceptual management innovation and setting out basic strategies. The output is innovative programs.
    c. Phase 3. Innovation planning - preparation of plans that include preparatory stages innovation plan in the medium term, implementation of conceptual intentions into the plan of creation of innovation plans, selection and inclusion of innovative actions, innovation plan breakdown. The output is a plan of development projects.
2. Stage of innovation solutions
    a. Phase 4. Planned solution of innovation - research and development solution of innovative actions, specifying their economic impacts and managing the progress of these actions, preparation production, import, supply, human resources and post-production design services innovative actions.
3. Stage of innovation realization
    a. Phase 5. Introducing Innovations into Production - Capability Verification Ready innovative actions in operating conditions. Measures for optimal implementation realization outputs, reaching the projected parameters of the innovation action.
    b. Phase 6. Permanent operation - use of implementation outputs of innovative actions, in specified scope and technical-economic lifetime, maintenance and gradual rationalization of implementation outputs. Complex evaluation innovation actions and comparison of original plans with their implementation, efforts further achieve the original intentions according to the knowledge of implementation and initial operation innovated production.
    c. Phase 7. Diffusion phase - commercialization and promotion, marketing [22]

The scientific literature does not define a uniform methodology for evaluating innovation, because it is a very unique issue that differs in many aspects across companies. Still, it would the assessment of innovation should not be forgotten. Each project manager should first set a target innovation, according to the objective and the nature of the company to set important evaluation criteria and compared with the results achieved.

Results and discussion

By implementing the abovementioned elements of the Industry 4.0 concept, by innovations the following improvements would be expected:

- Eliminate errors and delays in production due to late transmission of change information between sections, such as design to purchase, technology to production, from purchase to assembly,
- Reducing the number of defective products, manufactured parts according to invalid documentation,
- Increase machining productivity by utilizing real machine behaviour data during activities,
- Improve planning accuracy and planning changes based on already verified similar orders,
- Increased assembly productivity due to minor changes to the parts produced resulting from information about problems and shape change suggestions when installing previous parts,
- Reduce the cost of product design changes based on requirements production and use.

Based the company wants to prepare for the management of new tasks in the field of digitization, connectivity, new mobility and autonomous management. Innovations take place continuously. The following table No. 3

however gives a simple overview innovation related to Industry 4.0 that are in the automobile factory.

Table 6. Industry 4.0. innovations in automotive. *Source: Own processing*

Title	Description	Benefits
3D printing	Production of functional models' vehicles, pressure production injection molds aluminium casting, printing prototype vehicle parts from plastic or plastic components or metal.	Reduced production time pre - production wagons and components, production of parts with complicated internal shapes, financial savings when production start-up.
Drones in logistics	Use of equipped drones' camera during logistics inventory of outdoor packaging areas and monitoring areas.	Time saving, full flexibility in air benefit other perspectives and the associated improving ergonomics.
Intelligent conveyors	Installation of RFID chips and several sensors on each hinge body, for purpose checking its status and reporting wear of rollers, drive, insulation wear carbon etc.	100% inspection of hinges body, instant bad article identification the whole chain of hinges, Reduce / eliminate downtime.
Electronic Gloves	Electronic Glove with implemented scanner for data recording or control material.	Increase ergonomics, data collection, control of manual operations.
Robotic hand	Cooperating robot, testing lifetime and so-called haptics car interior buttons.	Precise tuning a long-term button testing, easier haptics setup and acoustics.
Simulation of paint shop in virtual reality	Display of paint shop in virtual reality using HTC Vive glasses for preventive purposes detection of a possible collision car body with paint robots during paint application.	Early prediction and detection collisions, downtime, time savings and of new costs painting programs.
Vibromonitoring	Early diagnostics of the end rotational lifetime (high speed I slow speed) and linear bearings on framers. Cranes for achieving maximum geometric accuracy	Time savings during downtime seizure of bearings and preventive maintenance.
Virtual Training	Supplement to the training of workers directly on the wagon assembly line by simulating errors and faults.	Save time to training workers during launch of new models and equipment.

The Industry 4.0 concept brings the benefits of increasing productivity, reducing costs and making mistakes they result from the involvement of more sophisticated machines in all company processes. Of course, there are some possible threats. More intensive integration of information technology into a complex system companies are threatened by cybercriminals. These could become part of an illegal competitive buoy. Only in the event of a few hours of failure do companies face major downtime and financial losses. Security systems companies are constantly developing new protection software, but crime is always one-step ahead. On the scale of large companies, there is a risk to the national level economy.

Employment is also an inherently affected area. Talking on the replacement of employees with more efficient machines and is expected to remain in companies mainly programming, maintenance and administrative positions. It is certain that this will be the case to occur gradually, and therefore current employees will have time and space to retrain, to do so it is necessary for the government to prepare the company for these changes, labour market and social policies.

Economic Impact

This manuscript demonstrates an impact of the innovations implementation Industry 4.0. principles, development of new products and services that improve productivity, efficiency, resilience and sustainability mainly in the automotive sector. At the end of the article, successful implementation is demonstrated by the development of future technologies in automotive and mechanical chemistry.

Conclusions

The introduction of new technologies and supply of innovative products are no longer enough for companies to remain competitive or to gain a sustainable competitive advantage. We are in a time when global trends, led by digitization, are dramatically changing the business environment. To ensure long-term success, companies need to rethink and innovate their business model. Industry 4.0 and digital transformation bring new opportunities in the areas of customer search, improving product offerings, and new opportunities for creating

and delivering value, thus opening up new ways to create profit. For companies to survive, it is essential that they respect these changes and adapt their business models to them.

Conflict of interest
There are no conflicts to declare.

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