SMART FACTORY FOR INDUSTRY 4.0: A REVIEW

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Abstract: Parallel to the development of information – communication technologies, the Internet, wireless networks, production networks, developed and industrial production which experienced a strong and profound changes. Factories have become more flexible than ever to complex modern market turbulence. Modern concepts of production systems require vertical and horizontal integration of all participants in the production process. This integration determines the foundation of a new, radical change in the mode of production by German industrialists called the industry is 4.0. In this, the smart production environment, structuring the smart factory. Smart factory is a production solution in a flexible and efficient way should be to meet the needs of today's market, and achieves integration between the various industrial and non-industrial partners who build dynamic, and very often and virtual organizations. This type of integration, linking the physical components of the production system and digital, abstract, virtual components into a single system called cyber – physical production systems. Systems are the backbone for the smart factory. Cyber – physical systems of production will be structured so that they can respond to almost any change in the market in time within really smart factories, but also beyond its borders. This not only makes production faster and in accordance with the specific requirements of individual customers, but also allows to production processes within the company are optimized through a network of global cooperation, adaptive and evolutionary and self – organizing. The potential for savings and innovation in these production systems and production operators is huge. Implementation of cyber – physical production systems in smart factories providing management with real – time, which is one of the fundamental principles of a new era in the sphere of industrial production.

Key words: Cyber-physical production systems, smart manufacturing, information-communication technology, real-time control, Industry 4.0.

1. INTRODUCTION

In the past twenty years, in the field of industrial production and development significant changes occurred. State and market borders are deleted, comprehensive globalization started to rule and the demand and supply of products is greater than ever. New technologies, especially information technology and information techniques, organization and logistics are implemented in modern business a system, which has led to new ways of production, new ways of doing business and better service activities in the sphere of industrial production.

The long-term technological and overall development, constant desire to direct nature laws, resources and new discoveries towards the general benefit of mankind led to the current high level of technological development. The biggest changes in technological development in the history of mankind took place in the last twenty years due to the rapid development of technology and informatics. Changes in the market caused the abandonment of the classical production methods and turning to the new requirements of the market. Such competition has affected the technical - organizational restructuring of production systems by concepts CEI (Computer Integrated Enterprise), CIM (Computer Integrated Manufacturing), FA (Factory Automation) and JIT (Just in Time), which lowers production costs, shorten production cycle and improves the quality of the product.

By deleting market boundaries and the emergence of the Internet new conditions are created for the development of new structures of production systems. Those production systems establish a new distributed adaptive production systems, production networks and automatically production systems. Due to the construction of such production systems limited number of interactions between participants in the production system is created and with that fact such production systems become unpredictable, their behavior and management is increasingly complex.

2. ASPECTS OF GLOBALIZATION

Modern market becomes more global and less national or local. Developed world market is reflected in the wide range of new products, the rapid obsolescence of products and the emergence of new products, high quality standards, short delivery and decreasing costs. Such conditions are very difficult for the classical industrial production we have today, and thanks to the progress of modern technological achievements, such as communication networks and the Internet, it is forcing us to develop and introduce a new modern era of industrial production based on communicational - informational linking of manufacturers and customers. This era, which is which sensors and chips identify and locate products, and in witch products know their history and current status. This network of machines, storage systems and manufacturing plants will exchange

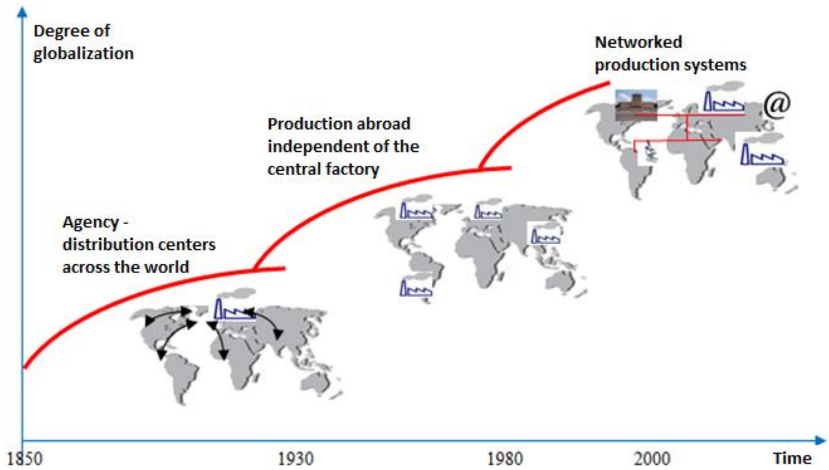

Fig. 1.The development of globalization in there fazes [1]

inevitably ahead of us is by the scientific circles of developed European countries cooled new industrial revolution or Industry 4.0.

The modern process of globalization is characterized by its essential dimensions. First, it marks the objective planetary processes:

•The essence of technological evolution; compression of time and space, reducing the distance and time required for more branched, global communication.

•Close connection and interdependence of societies; everything is in a wider range of activities that have become transnational, and can not be managed solely within the individual states.

Globalization means the spread of identical form (industrialism and then post-industrialism, market economy and multi – party political system) to almost the entire social world space.

3. ON THE WAY TO INDUSTRY 4.0

Today we are on the threshold of a new industrial revolution, the revolution by which digital networks are related to operating values in the intelligent factory, and that includes everything from the initial idea, through design, development and manufacture, to maintenance, service and recycling.

Industries 4.0 include horizontal integration of data flow between partners, suppliers and customers, as well as vertical integration within the organizations frames - from development to final product. It merges the virtual and the real world. The result is a system in which all processes are fully integrated - system in information in real time frame. The speed and rate of changes in consumer trends will be a significant driver of Industry 4.0.

Since the products are configured to respond to the preferences of individual users, production must be more flexible and must be shorter.

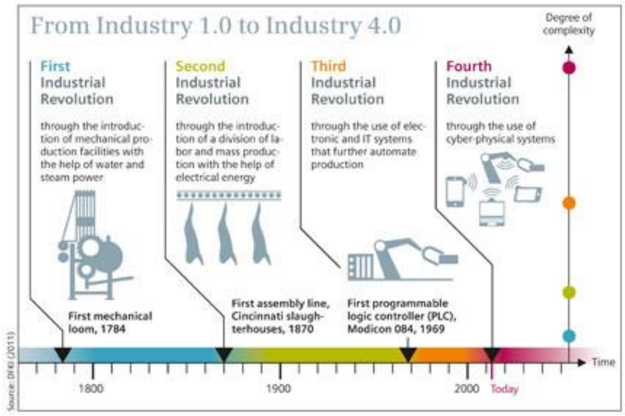

Fig. 2.Industrial revolution [2]

The point is to create value for customers, and that means to involve them in the process from the beginning. Of course, the companies that use the highly efficient mass production to achieve economies of scale are in benefit, while at the same time they have the opportunity to offer a high level of adaptation.

4. CYBER – PHYSICAL SYSTEMS – THE BASIS FOR A NEW PRODUCTION ERA

The industry of developed countries in Europe and North America are based on the exploitation of cyber - physical systems through technology based on the integration of wireless systems, wireless control system, machine learning, and production – based sensors [3]. Such industries are developing a national platform for new production systems and new age of 4.0 Industry – based access to the Internet and Cyber - Physical Systems (CPS).

Cyber - physical systems are a new generation of systems that integrate computer and physical abilities. With the combination of cyber systems and physical systems user semantic laws can be traced and thus communicate with people. Cybernetic systems are a summation of logic and sensor unit, while the physical systems summation of actuator units. Through the ability to interact and expansion capabilities of the physical world using computing power, communication technologies and control mechanisms, cyber – physical systems allow feedback loops, improving production processes and optimum support of people in their decision – making processes [4].
By using the corresponding sensor technology, cyber - physical systems are able to receive direct physical data and convert them into digital signals. They can share this information and access the available data that connects it to digital networks, thereby forming an Internet of things [5].

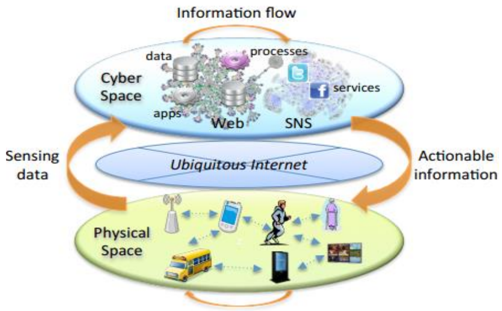

Fig. 3.The flow of information between the physical and cyber world [6]

In the simplest definition, cyber – physical systems are the integration of computers, networks and physical systems, [7].
Cyber - physical systems are undoubtedly the integration with embedded systems and systems in real time, or (Real - Time Systems). In this kind of integration is teamed multitude of tools and systems, such as engineering systems based on knowledge, artificial intelligence, existing installed systems, which are all together transformed into a new system called cyber – physical systems, [8].
Cyber - physical production systems (CPPS), relying on the latest development of computer science (CS), information and communication technologies (ITC), manufacturing science and technology (MST), can lead to a new industrial revolution, or often in scientific circles called Industry 4.0, [9].
Cyber – physical production systems consist of autonomous and cooperative elements and subsystems, connecting communications and interactions in different situations, at all levels of production, of machines, processes to manufacturing and logistics networks. Their operational modeling and forecasting allows the implementation of a series of basic applied – oriented research tasks, and above all controlled systems at any level. The basic assumption in terms of cyber - physical production systems is reflected in the research and defining relations through the prism of autonomy, cooperation, optimization and response to the assigned tasks. By integrating analytic and simulation-based approach may this prediction be described in greater detail than ever before. Such systems must confront a series of new challenges in terms of operational sensor networks, smart actuators, databases and many others, above all, communication protocols, [10].
CPPS partly break with the traditional automation pyramid (left side of Fig. 4). The typical control and field levels still exist which includes common PLCs close to the technicalprocesses to be able to provide the highest performance for critical control loops, while in the other, higher levels of the hierarchy a more decentralized way of functioning is characteristic in CPPS.

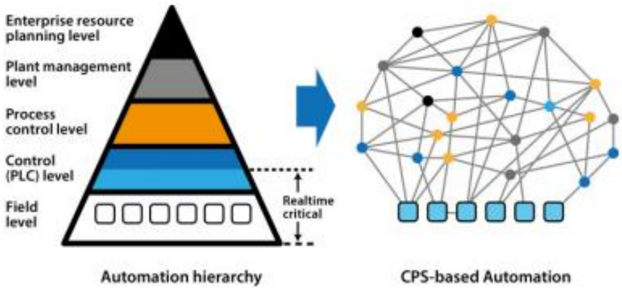

Fig. 4.Automatic decomposition hierarchy with distributed service, [11]

CPPS will enable and support the communication between humans, machines and products alike.
The elements of aCPPS are able to acquisition and process data, andcan self – control certain tasks and interact with humans via interfaces, figure 5.
Parallel development of computer science and information - communication technologies undoubtedly led to a close compression of the physical and virtual world with reflection on production systems causing the construction of new production systems based on cyber - physical connections.

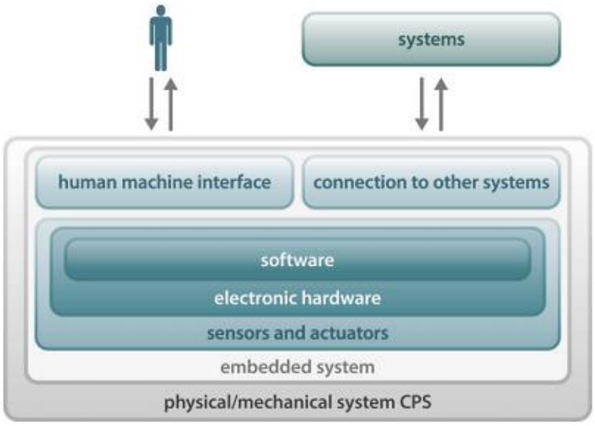

Fig.5.Interaction between humans and machines in cyber – physical, [12]

5. PRODUCTION FOR INDUSTRY 4.0

Production of new generation should be adjusted to changeable conditions and issues put before it. Optimization of plant operations will be implemented by improving and speeding up communications. Starting points are the solutions offered by a vision of "smart environment" for production.
Based on this, in the book "Smart Factory", smart factory is defined as factory workers and machinery related to the execution of their tasks [13].
People today are surrounded by a lot of things that we call smart things. Almost everyone has a smart – phone, some people have smart homes [14], which are connected to smart grids. The South Korean government in collaboration with local industry has seven initiated projects to build smart cities [15].
In order to create a large-scale smart system smart devices are used [16]. The term smart (often used to mark intelligence) seems to be applicable in different contexts, because its meaning with respect to objects is not yet clearly defined.
Smart, in some contexts, refers to an independent device, which usually consists of the sensor, and / or to activate the microprocessor and transceiver [17].
However, adjective smart is used to characterize and that contributes to the implementation of additional meanings, which introduced multi-platform communication and increase its computing capacity. Intelligence is revealed through cooperation in networks with other smart devices, which have the possibility to check the system updates and decide whether to act on them or not. Such a network is called smart grid [17]. They may find a reference to smart objects, as objects that have the ability to connect the stored data, as well as offer access to it for human or machines needs. There are so much smart products that are equipped with memory options that they can be understood as a kind of living product [2].

6. SMART FACTORY

The term smart factory is used in industry practically and scientifically, although there is no consistent definition. There are several other terms used for this purpose: U – Factory (ubiquitous factory) [18], the factory of things [13], the factory in real time frame [19], or the intelligent factory of the future [20]. Scientists use the term smart manufacturing technology, the approach [19][21], or paradigm [18].
All the terms and concepts above are very promising prospects for the upcoming technological development. However, although the engineers and scientists are constantly working on these terms, they remain just a vision. Despite all, this success story is a long and winding road that goes into a multidimensional problem to solve, before you are able to be a part of this vision of the smart factory in reality. Zuehlke estimates that the development of technology will last for at least 5-10 years [19].

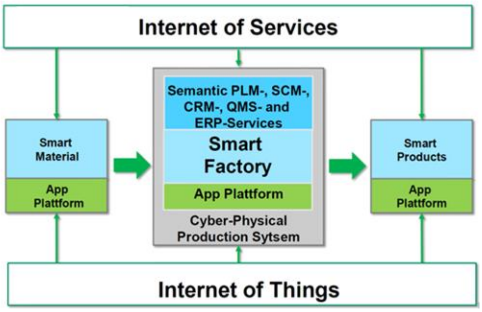

Fig. 6.Smart Factory, [22]

Based on the analysis of the future production literature, characteristics that are desirable for smart factory would relate to the flexibility and re – configurability, low cost and changeability, agility and slenderness. One way to achieve some of these functionalities is apply modularity with respect to the application of the product/ process technology and organization.
Based on this, we propose a conceptual definition, [23]:
A Smart Factory is a manufacturing solution that provides such flexible and adaptive production processes that will solve problems arising on a production facility with dynamic and rapidly changing boundary conditions in a world of increasing complexity. This special solution could on the one hand be related to automation, understood as a combination of software, hardware and/or mechanics, which should lead to optimization of manufacturing resulting in reduction of unnecessary labour and waste of resource. On the other hand, it could be seen in a perspective of collaboration between different industrial and nonindustrial partners, where the smartness comes from forming a dynamic organization.
With the rapid development of Internet technology and network systems it is possible to think, but it is also opened the way for the development of intelligent machines that will in some time have the ability to think, learn, remember and in a given moment share that amount of knowledge, or react in certain situations. Regardless, what now sounds abstract, it is expected that the smart machines in the near future will shape jobs, manufacturing processes and production systems.
Intelligent product is a metaphor for reducing media crushed and frequent interruptions based in a single product. These media breaks in production often lead to losses and a decrease in productivity. The system configuration in the domain of information about the products, their production parameters, requires intelligent product, available at the right time in the right place and that can be digitally processed. In regard to this, the production history of intelligent products is directly recorded on the product itself, which makes the process faster and more efficient. So, intelligent product

becomes the medium for the transmission of information about production processes, stages of the process and characteristics of the product itself, [24].

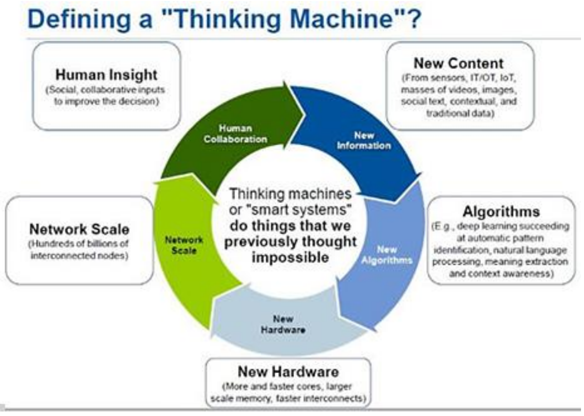

Fig. 7. Smart Machine

Development in the field of computer technology directly influenced the development and improvement of sensor technology, especially when it comes to intelligent sensors. ISA (International Society of Automation) defined sensor as a device that provides an appropriate output in response to a specific measured value. Most sensors essentially behaves as a passive device, such as a resistor, whose values change depending on the external excitation.
The sensors do not function independently, but are generally part of a larger system that contains conditioners signals as well as different analog and digital circuits for signal processing. The system can be a measuring system, the data acquisition system, or a system of process control.
A key feature of intelligent sensors is that it processes the input signal at a logical level, in order to increase the level of information processing. The sensor is able to make a logical decision on the level of information (for some of the original information).It is able to execute the action depending on that information, or can transmit a message to a higher level. Other features include intelligent sensors in their ability to self-test, a variable calibration, improved rejection of false inputs (noise), and easier to set up and use.

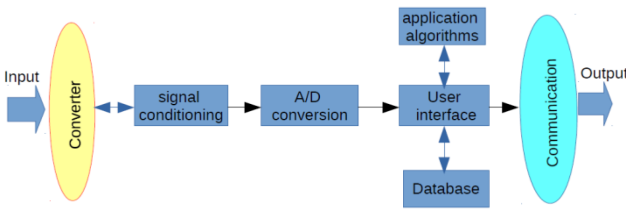

Fig. 8. Architecture of an intelligent sensor, [25]

Microelectronics, as a part of microprocessor technology, by entering in the n the production of sensors it self has allowed many more functionality, such as the possibility of installing intelligent and digital communications in the sensor. This allows the translation of a sensor in the digital domain. Traditionally the sensors outputs are analog signals, which are still in an instrumentation system or directly displayed (On a display). This migration from analog sensors in the digital domain has brought significant benefits to users, such as digital sensors are much more resistant to electrical noise and can significantly simplify their relationship sachems. Manufacturers of intelligent sensors are trying to make intelligent sensors that cost less, are able to meet the needs of increasingly complex applications and are easy to handle. Networking sensors, technology that was created by modifying the electronic and PC is slowly assuming all areas in industrialized countries and it is causing significant progress in the so – called business sensor.
Actuators or drives are mechanical devices that allow a person to apply a specific proposal indirectly on the product or process, rather than by hand. Individuals can control actuators or manually manipulate with the help of computer software or interfaces. Drives manipulated by programmable logic or computer are known as "smart" drives. Today there are different types of actuators. The two most common types are flat or linear motion and circular actuators with a circular motion. The main purpose of an actuator is to enable force or movement to be played to a product that would otherwise be moved manually.
Advantages of the system of smart actuators, as a whole, is that it can include precise repetition; increase the speed of production; and reduced human interaction, which is useful for production where it is necessary to prevent health risks. Another important benefit of the system of smart actuators is that production runs around the clock, because machines do not require frequent resting like people do. Proper implementation of smart actuators can lead to great increase the profits of the production system by reducing the manpower needed to manipulate the products.
The Internet of Things (IoT) is a novel paradigm that israpidly gaining ground in the scenario of modern wireless telecommunications. The basic idea of this concept is the pervasive presence around us of a variety of things or objects – such as Radio – Frequency IDentification (RFID) tags, sensors, actuators, mobile phones, etc. – which, through unique addressing schemes, are able to interact with each other and cooperate with their neighbors to reach common goals, [26].
According to Cluster of European research projects on the Internet of Things, [27]:
‘Things’ are active participants in business, information and social processes where they are enabled to interact and communicate among themselves and with the environment by exchanging data and information sensed about the environment,

while reacting autonomously to the real/physical world events and influencing it by running processes that trigger actions and create services with or without direct human intervention.

7. INTERNET OF THINGS

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According to Forrester [29], a smart environment is:

Uses information and communications technologies to make the critical infrastructure components and services of a city's administration, education, healthcare, public safety, real estate, transportation and utilities more aware, interactive and efficient.

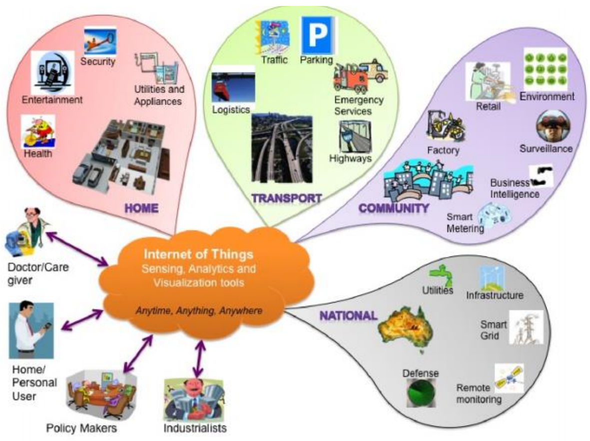

Fig. 9. Internet of Things [28]

Roughly speaking, the Internet of Things means a worldwide network of interconnected and uniform addressed objects that communicate via standard protocols [30]. In such networks, a large number of devices (heterogeneous) present a unique address for data exchange, which is a difficult problem. The solution to that, many see in the use of semantic technologies, which have inspired the third, semantic set of definitions.

RFID Technology

Radio frequency identification (RFID) was conceived as a simple replacement of bar codes where the product identification is carried out wirelessly via radio waves. By using such a system certain restrictions that exist in the use of bar codes are removed, such as for Eg. the need for direct visibility of the code by the reader, a small distance at which it can be read, the problems with damaged labels with bar codes, slowness in reading more quantity of products etc.

Active RFID readers have their own battery power and can initiate communications. From multiple applications [30], [31], the main application of the active RFID tag is in port for containerized cargo tracking. The main segments of RFID systems RFID tags, RFID reader and a computer. RFID tag is a carrier of product, such as a bar code. It consists of a memory chip and a transmitter that communicates with the RFID reader.

RFID technology has some great advantages and disadvantages with respect to the bar code. Products marked with RFID tags can be read even in cases when they are not directly accessible to the reader. Data can be read from a distance up to 10 meters. Speed of reading is very large, so that in one second can be read hundreds of tags. Unlike bar codes, which can easily be damaged and thus lose information, RFID tags are highly resistant to physical damage. In the RFID tags corresponding species subsequently, the necessary information may be added.

Unlike the bar code technology, which is cheap, the RFID technology is significantly more expensive. Since it is based on radio waves, suffers from a lack of radio communication: radio waves misbehave in humid conditions, in the presence of higher amounts of metals in the environment and in the presence of "electronic noise". A variety of data that neds to encode in RFID tags causes more expensive products because of the need to make bigger memory chips. This increases the time required for reading and transferring data. In subsequent recording of information in RFID tags is necessary to provide security mechanisms to prevent the recording of false information by unauthorized persons [32].

Expectations of advanced production system in the announced new Industrial revolution:

By developing cyber - physical system, and therefore their implementation in smart factories, one can expect significant improvements in production systems that will be reflected in the form [10]: Robustness at all levels; Self - organized, self - maintenance, self - refurbishment, generalization; Security; Remote diagnosis; Control in real time; Autonomous management; Transparency;
Predictability; Effectiveness, efficiency etc.

Through the development of cyber – physical systems, it is expected new business models and new services to be developed and implemented in various aspects of our lives. Cyber – physical systems contribute to finding answers to the key challenges of our society and are very important in many industries and application areas. Cyber – physical systems provide enterprises support in the process of optimization and therefore also in the price of aspiration to save time.

Cyber – physical systems are of great importance in the industrial production, in order to meet customer requirements. Production systems will be structured so that they can respond to almost any market changes in real time and supply chain using cyber – physical systems, wichcooperate with the ultra – flexibility, even outside the company. This not only makes the production of high –speed in accordance with the specific requirements of individual customers, it makes the production processes within the company optimized through a network of global co - operations. Advanced systems will become adaptive, evolutionary and thought self – organizing production systems. The potential for savings and innovation in these production facilities is huge.

The following topics, related to cyber – physical production systems and smart factory are of the biggest importance for the production and engineering in the upcoming Industry 4.0:

-Further research and development of innovative methods so that they are able to offer new products for the global market;

-Ongoing research into new production processes;

-A further breakthrough in manufacturing processes and production equipment, in order to be properly established available models which can be used as a cyber – physical production systems;

-The robust, fast, efficient production processes, which can be performed safely without human intervention and verification;

-Stable machines with predictable properties and behavior in order to understand the security automation, even under fluctuating environmental protection requirements;

-Models and simulation procedures for processes and machines to introduce automation systems with methods of assessing the implications of their decisions;

-Safe processes for cyber – physical systems, which can be launched even under difficult circumstances and conditions of the system and at high speed, to ensure that neither people nor machines are not in danger;

-Security in networks, in order to avoid the abuse and neglect from the inside and outside;

-Extreme ability in real time to reach even the fastest processes, incidental and mutual;

-New models of operators;

-Hybrid systems and architecture models for engineering jobs, and

-Sustainable design manufactures (roundabout economy).

These points include lots of keywords that provide a starting point for technical research in the field of smart factory production [33].

8. CONCLUSIONS

Retrospectively looking at previous revolutionary development of manufacturing from its beginning until today, we see that the period between these revolutions drastically reduced and that rapid steps we are walking into the future.The emergence of the Internet and Internet technologies of modern times undoubtedly made a big progress in all human activities. It is inevitable integration in production systems, which will further affect the increase in the complexity of the existing production systems, as well as new systems coming to us, such as cyber – physical production systems.The development of production systems in the spirit of cyber – physical production systems, use of digitization and e - business imperative is to aspire to smart factories – factories of the future.

Machines take up the human role in factories. But still the human integration is inevitable with a digital, electronic, virtual world, so that our work is preceded by further development of production systems in terms of reliability, efficiency, safety, etc. The current and future development is characterized by profound and rapid scientific and technological changes, which result with reindustrialization existing industries and the revitalization of a wide range of human activities and public functions in private life.

Technological development, as the most important factor and an important prerequisite of general development presupposes the development and application of new technologies and imposes the need for restructuring of existing, as well as designing new plants with new settings (fractal, virtual factory). Therefore, the necessary rapid and immediate change in the existing situation is needed, and it must include:

-General support in defining a development strategies and policies of its realization,

-Strategically oriented factors, research institutions and supporting institutions,

-Industrial organized development of new scientific knowledge and their direct transfer into the economy of the region.

Simultaneous changes are possible only on the basis of unique development strategy in which an important place should take the establishment of regional, especially innovation networks of smart factory, which should be the generator of new products, services and job creation.

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