Manufacturing Systems Processes Framework Category For The Future Production Based On Industry 4.0 Techniques And Approaches

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Abstract - Recent concepts such as the Internet of Things, Industrial Internet, Cloud-based Manufacturing and Smart Manufacturing address this vision of future digitally enabled production and are commonly subsumed by the visionary concept of a Fourth Industrial Revolution or Industry 4.0. All these concepts are related to recent technological developments where the internet and supporting technologies e.g. embedded systems serve as a backbone to integrate human and machine agents, materials, products, production lines and processes within and beyond organizational boundaries to form a new kind of intelligent, connected and agile value chain. Industry is currently undergoing a transformation towards full digitalization and intelligentization of manufacturing processes. Although a common agreement exists on the necessity for technological advancement of production technologies and business models in the sense of Industry 4.0, a major obstacle lies in the perceived complexity and abstractness which partly hinders its quick transformation into industrial practice. The concept is built upon a tentative competency model for Industry 4.0 and the use of scenarios for problem-oriented learning of future production engineering. In this paper we focus on a taxonomy of required skills and competencies with regard to the challenges of the framework category for the future production based on Industry 4.0. The future of production as it is envisioned by Industry 4.0 is characterized by small decentralized and digitalized production networks efficiently controlling their operations in response to changes of the environment and strategic goals.

Keywords: *Industry 4.0, Smart Manufacturing, Learning Factory, Scenario-Based Learning (SBL), Integrative Product Engineering Process" (i-PEP), Internet of Things, Industrial Internet, Cloud-Based Manufacturing.*

I. INTRODUCTION

The term Industry 4.0 stands for the fourth industrial revolution which is defines as a new level of organization and control over the entire value chain of the life cycle of products, it is geared towards increasingly individualized customer requirements (M. Rüßmann et al., 2015). The main difference between industry 4.0 and Computer Integrated Manufacturing (CIM) is the concern of the human role in production environment. Industry 4.0 has an important role of human worker in performing the production where as CIM considered workerless production (K.D. Thoben et al., 2017).

The Industry 4.0 paradigm promotes the connection of physical items such as sensors, devices and enterprise assets, both to each other and to the Internet (K. Sipsas et al.,2015) Designing and drafting methods in all disciplines should be reviewed and their suitability be checked for a modern, interdisciplinary approach model for product development and transferred to a common, integrated and interdisciplinary methods, process and IT solution (F. Rennung et al., 2016). The production process is divided into small value oriented units which shares information of the consecutive process steps only which helps in increasing flexibility and probably results in reduction of complexity of coordination (M. Brettel et al., 2014).

The German Federal Government presents Industry 4.0 as, an emerging structure in which manufacturing and logistics systems in the form of Cyber Physical Production System (CPPS) intensively use the globally available information and communications network for an extensively automated exchange of information and in which production and business processes are matched (MAK. Bahrin et al., 2016).

The four main drivers of Industry 4.0 are Internet of Things (IoT), Industrial Internet of Things (IIoT), Cloud Based Manufacturing and Smart Manufacturing which helps in transforming the manufacturing process into fully digitized and intelligent one (S. Erol et al., 2016). The nine pillars of Industry 4.0 will transform isolated and optimized cells production into a fully integrated, automated, and optimized production flow. This leads to greater efficiency and change intraditional production relationships among suppliers,producers, and customers as well as between human and machine (M. Rüßmann et al., 2015).

1.1 Additive Manufacturing: With Industry 4.0, additive- manufacturing methods will be widely used to produce small batches of customized products that offer construction advantages, such as complex, lightweight designs. High- performance, decentralized additive manufacturing systems will reduce transport distances and stock on hand (M. Rüßmann et al., 2015). As the needs of customer is changing continuously the challenge of increasing individualization of products and reducing time to market are faced by many companies. These challenges they encounter in particular with increasing digitization, IT penetration and networking of products, manufacturing resources and processes (F. Rennung et al., 2016). Decreasing product life cycles in combination with the growing demand of customized products asks for the further transformation towards organization structures which lead to increased complexity (M. Brettel et al., 2014).

1.2 Industry 4.0 Production System (Smart Factory)

The core process is digital to physical conversion in areconfigurable manufacturing system. Reconfigurable manufacturing systems are the latest advance in the development of a manufacturing system as shown in Fig. 1.

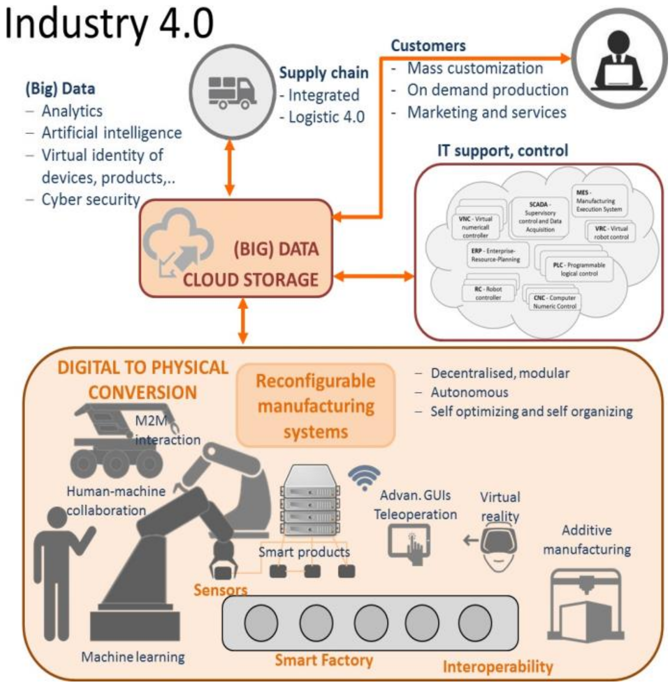

Fig.. 1. Industry 4.0 Smart Factory

First step were fixed production lines with the machines dedicated to the performance of specific tasks so only one product could be produced. Next step were flexible production systems with programmable machines that allowed production of a variety of different products but offered no flexibility in the production capacity. As the results of the latest development are reconfigurable manufacturing systems able to adapt their hardware and software components to follow ever- changing market requirements of type and quantity of the products. Machines in Industry 4.0 factory are Cyber-Physical Systems, physical systems integrated with ICT components.

They are autonomous systems that can make their own decisions based on machine learning algorithms and real-time data capture, analytics results, and recorded successful past behaviours. Typically, programmable machines (CNC and NC) are used, with a large share of mobile agents and robots able of self-organization and self-optimization. (Andreja Rojko, 2017). Software tools are crucial for operating of the Industry 4.0 smart factory. The well known pyramid structure of support software of modern production systems. On the business level, the Enterprise Resource Planning (ERP) tool is implemented.

ERP supports enterprise-wide planning such as business planning, supply chain management, sales and distribution, accounting, human resource management and similar. Usually commercially available solutions are implemented. Currently the leading solution is SAP, by the German company (SAP SE, 2016). In traditional ERP tools, the decision process is centralized on the highest level in the automation pyramid. Most of the available ERP solutions do not support fast adaptation in production planning due to the unplanned events.

The second level in the traditional automation pyramid is Manufacturing Execution System (MES). It supports production reporting, scheduling, dispatching, product tracking, maintenance operations, performance analysis, workforce tracking, resource allocation and similar. It covers aspects such as management of the shop floor and communication with the enterprise (business) systems. Most of the software solutions available on the market are centralized and not distributed to the shop floor elements.

This is a major limiting factor when flexibility is needed due to the dynamics of customers' order flow and/or changing production environment, including shop floor configuration. The next operative level is process level control based on Supervisory Control and Data Acquisition (SCADA) control system architecture followed by controllers on machine/devicelevel such as Programmable Logic Controllers (PLCs), robot controllers and other controllers as shown in Fig. 2.

The last level of the automation pyramid is a machine/device level. In opposition to the top two layers, this level has a naturally distributed control level.

ERP and MES tools represent basic software in the company and are used since the nineties. Both systems have typically a modular structure but are centralized in their operation and thus have limited capability for dynamic adaptation of the production plan. Nevertheless, already implemented conventional ERP and MES systems should not be seen as main obstacles to the introduction of the Industry 4.0 concept but more as a step towards it. Namely already the introduction of a common MES tool requires advanced IT infrastructure on the shop floor level and this is also a precondition. for further development towards smart factory. (Andreja Rojko, 2017).

Industry 4.0 provides numerous benefits, for example the reduction of labour costs, the simplification of business processes and the reduction of inventory inaccuracies, as well as more transparency in logistics processes (Logistics cost ; Delivery time; Transport delay Changes in amount of delayed shipment; Inventory reduction ; Loss/damage ; Frequency of service ; Forecast accuracy ; Reliability ;Flexibility ;Transport volumes ; Applications and so on). All of these are keys to increased productivity and revenue which can, hence, stimulate economic growth .

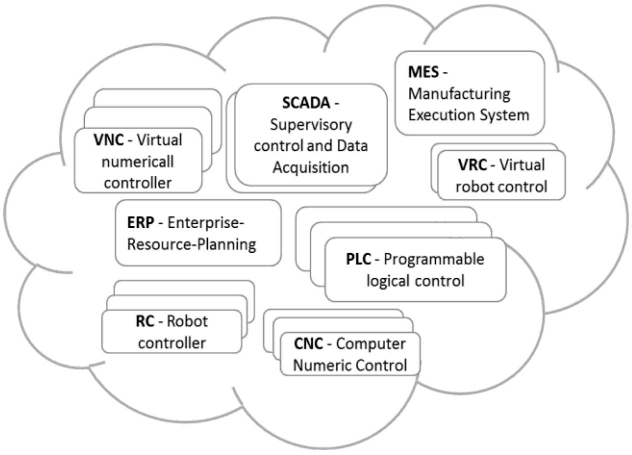

Fig. 2. Industry 4.0 Structure Of IT Support And OperativeLevel Control In The Industry

II. THEORETICAL FRAMEWORK OF INDUSTRY 4.0

The Internet transformation of the digital industry is still inprogress, but artificial intelligence, big data, and connectivity indicate the certainty of a new round of digital revolution. Industry 4.0 is on the way and will have an important influence on the complete transformation of industry because it represents progress on three points.

2.1. Digitization of Production: Information systems formanagement and production planning.

2.2. Automation: Systems for data acquisition from theproduction lines and using machines.

2.3. Linking manufacturing sites in a comprehensivesupply chain: Automatic Data Interchange.

Characteristic of Industry 4.0 is increased competitiveness through smart equipment, making use of information about high-wage locations, demographic changes, resources, energetic efficiency, and urban production (Heck et al., 2014). The four key components of Industry 4.0 are cyberphysical systems (connections between the real and virtual world), the IoT, the IoS, and the smart factory. Machine communications (M2M) and smart products are not considered as independent parts. The M2M is an enabler of the IoT. Smart products are a subcomponent of the Cyber Physical Systems (CPS) (Greengard, 2015 & Kagermann, 2014).

- Reduction of overproduction and waste.
- Reduction of energy consumption as energy intensive tasks can be done when there is overproduction. Use of energy recovery for the whole system.
- Reduction of waste especially in the product developmentphase.
- Reduction of transportation and travel effort and Savingof natural resources.
- Contribute to the environmental dimension of existingmanufacturing plants (M.W. Waibel et al., 2018)

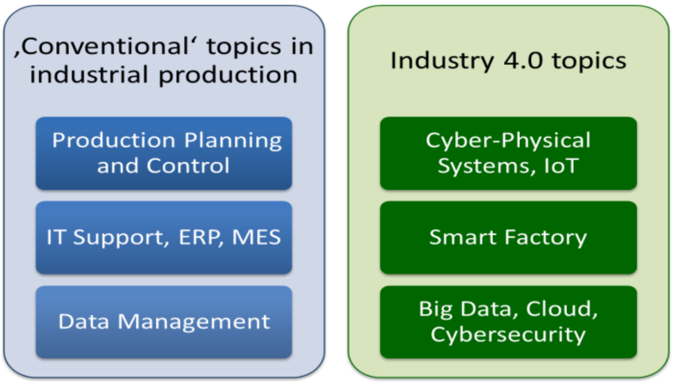

Fig. 6. Comparison of Topics In Conventional IndustrialProduction And The Industry 4.0 Topics

- Decentralized and digitalized production, where theproduction elements are able to autonomously control themselves .
- The products will become more modular and configurable, promoting mass customization in order to meet specific customer requirements

2.4 New innovative business models: value chains are becoming more responsive, increasing competitivenessthrough the elimination of barriers between information and physical structures

- Digitization consists in convergence between physical andvirtual worlds and will have a widespread impact in every economic sector.
- The main driver for innovation, which will play a critical role in productivity and competitiveness.

2.5 Transforming jobs and required skills: avoid what is known as technological unemployment, redefining current jobs and taking measures to adapt the workforce for the new jobs that will be created. New competencies and it is necessaryto create opportunities for the acquisition of the requiredskills through high quality training. (Pereira et al., 2017)

- Workers will have a much greater share of doing complex and indirect tasks such as collaborating with machines in their daily work.
- Workers will have to (1) solve unstructured problems, (2) work with new information, and (3) carry out a number of non-routine manual tasks.
- **Logistics cost:** Changes in logistics cost savings in terms of transport, warehousing, inventory carrying and administration costs.
- **Delivery time:** Changes in delivery improvements, cycletime, lead time
- **Transport delay:** Changes in amount of delayedshipment
- **Inventory reduction:** Changes in inventory volume
- **Loss/damage:** Changes in amount of lost and/or damagedgoods from damage, theft and accidents
- **Frequency of service:** Changes in utilization rate (loadfactor), frequent intervals
- **Forecast accuracy:** Changes in demand uncertainties
- Reliability : Changes in logistics quality in terms of transport, inventory and warehousing e.g. perfect order, scheduled time deliveries
- **Flexibility:** Changes in planning conditions e.g. percentage of non-programmed shipments executed without undue delay
- **Transport volumes:** Changes in total transported freight volume
- **Applications:** Suitable applications for digitization in logistics processes (Yasanur Kayikci et al., 2018). Large increase in all operational efficiencies with the use of data levering to improve processes. Industry 4.0 is seen as one of the major drivers for the growth of revenue levels, evenas its implementation will also require significant investments by businesses. logistics and statistics are generated and collected in an automated manner.
- **Increased productivity:** Revenue will increase faster and higher than the costs incurred to automate or digitise the manufacturing process in terms of Industry 4.0. Industry 4.0 concepts and methods applied, logistics and statistics are generated and collected in an automated manner, so responses are faster. (Koch et al. 2014)

Table 1. The Evolution of Production.

Source: (Beata et al., 2017)

	Past	Prsent	Future
Communi cation System	Analog	Internet and Intranet	Internet of Things. Cyber Physics System
Concept	Neo-Taylorism	Lean Production	Smart Factory
Solution	Mechanizati on and automation	Automation and computerization	Virtualizat ion and integration

The technologies, which have been already implemented, should be modified to fulfill the special requirements of manufacturing technology, research and development work in a new production location and market (Beata et al., 2017). The attention should be paid to three types of integration: horizontal, vertical and end-to-end integration. (Shafiq SI etal., 2015) & (Stock T, 2016). Horizontal integration refers to a generation of value-creation networks involving integration of different agents such as business partners and clients, and business and cooperation models, whereas, vertical networking concerns smart production systems, e.g.: smart factories, smart products, the networking of smart logistics, production and marketing and services, with a strong needs- oriented (Stock T, 2016). End-to-end integration is targeted at gaining on product design, manufacturing and the customer (Shafiq SI et al., 2015). However, according to (Deloitte, 2014) it is possible to differentiate four integrations, where the first two are the same, but they added two more such as through-engineering across the value chain and exponential technologies. (Shafiq SI et al., 2015). & (Deloitte, 2014).

Table 2. System Integration, Source: (Saurabh et al., 2018)

System Integration		
Horizontal Integration across the entire value creation network	Vertical Integration and networked manufacturing systems	End to End Integration across the entire product life cycle

Even though complexity of Industrie 4.0 system is growing it has a huge potential which is as follows (Shafiq SI et al., 2015). & (Deloitte, 2014).

- Specialized industry-specific solutions ("pull from the customer") and individualized understanding of customers needs even in a case of manufacturing one-off items, having very low production volumes (batch size of 1) and still gaining a profit. (Beata et al., 2017)
- Increase competitiveness and flexibility resulting from dynamic structure of business processes (i.e. quality, time, risk, robustness, price and eco-friendliness), adjustment to changes in demand or breakdowns in the value chain. (Beata et al., 2017)
- Optimized decision making due to end-to-end visibility inreal time. (Beata et al., 2017)
- Increasing resource productivity (providing the highest output of products from a given volume of resources) and efficiency (using the lowest possible amount of resources to deliver a particular output). (Beata et al., 2017)
- Value opportunities (innovative services, new forms of employment, opportunities for SMEs and startups to develop B2B services). (Beata et al., 2017)
- Keeping productive workers for longer proving them diverse and flexible career paths and Work-life-balance (Beata et al., 2017).
- High-wage economy with tied-up capital cost, cut energy costs and reduced personal cost. (Beata et al., 2017)

III. CHALLENGES AND ISSUES IN INDUSTRY 4.0

There are some challenges and fundamental issues occurs during the implementation of industry 4.0 in the current manufacturing industries (Saurabh et al., 2018) listed below.

3.1 Intelligent Decision-Making and Negotiation Mechanism: In smart manufacturing system needs more autonomy and sociality capabilities as key factors of self organized systems whereas the today's system have 3C Capabilities i.e. lack of autonomy in the systems (Wang S. et al., 2016).

3.2 High Speed IWN Protocols: The IWN network used today can't provide enough bandwidth for heavy communication and transfer of high volume of data but it is superior to the weird network in manufacturing environment (Wang S. et al., 2016).

3.3 Manufacturing Specific Big Data and Analytics: It is a challenge to ensure high quality and integrity of the data recorded from manufacturing system. The annotations of the data entities are very diverse and it is an increasing challenge to incorporate diverse data repositories with different semantics for advanced data analytics (Thoben et al., 2017).

3.4 System Modeling and Analysis: In system modeling, to reduce dynamical equations and conclude appropriate control model, systems should be modelled as self-organized manufacturing system. The research is still going on for complex system (Wang S. et al., 2016)&(Saurabh et al., 2018).

3.5 Cyber Security: With the increased connectivity and use of standard communications protocols that come with Industry 4.0, the need to protect critical industrial systems and manufacturing lines and system data from cyber security threats increases dramatically (M. Rüßmann et al., 2015).

3.6 Modularized and Flexible Physical Artifacts: When processing a product, Equipment for machining or testing should be grouped and worked together for distributed decision making. So there is a need of creating modularized and smart conveying unit that can dynamically reconfigure theproduction routes. (Saurabh et al., 2018).

3.7 Investment Issues: Investment issue is rather general issue for most of new technology based initiatives inmanufacturing. The significant investment is required for implementing industry 4.0 is an SME initially. The implementation of all the pillar of industry 4.0 requires huge amount of investment for an industry (Wang S. et al., 2016) & (Saurabh et al., 2018).

IV. IoT IN THE FRAMEWORK OF KNOWLEDGE MANAGEMENT (KM)

The IoT includes "things" and "objects" like radio- frequency identification (RFID) sensors that will send storage, processing, and analysis information, and smartphones that interact with each other and cooperate with smart components (Dutton, 2014). This leads to a new functionality of KM (Knowledge Management) processes and involves new functionalities for CRM, Customer Support Systems orCustomer Relation Management, and Enterprise Resource Planning (ERP).

The new role of IoT CRM will be to help companies better understand their customers and offer proactive support by leveraging IoT data to create improved, automated customer support environments. Companies will have the opportunity to manage customers with customer support systems in real-time marketing promotions on demand pricing, next generation customer service, and in-store experiences (Goldenberg,2015).

ERP regarding the IoT is connected with establishing smart factories that involve manufacturing equipment that is capable of reading and storing data about activity related to production, energy, time, and other process-related parameters. The IoT allows monitoring of all manufacturing processes with the purposes of maintenance, production quality, and energy management optimization.

The goal of the smart factory is to connect all smart devices with higher decision making. This connectivity from the device level to the organizations' decision making–level connection involves connecting smart factory devices to manufacturing execution systems (MESs), energy management systems (EMSs) or ERP systems (Gamarra et al.,2016 & Montero, 2016). If KM in the period of its creation proceeded on the assumption that there is a benefit to knowledge upgrading, all that is needed is to capture, decode, and share. At this stage, the purpose of KM is to provide a means to increase the development of knowledge and transfer it into practice (Ray et al., 2017).

The first period of KM emphasizes the integration of knowledge. The second generation of KM is based on the assumption that it is necessary to produce knowledge in the social environment. The knowledge thus generated through processes of individuals and exchange of knowledge also needs mechanisms to assure its accuracy. This process at an organizational level is defined as the knowledge life cycle.

4.1. Intelligent Manufacturing

The Industry 4.0, manufacturing systems are updated to an intelligent level. Intelligent manufacturing takes advantage of advanced information and manufacturing technologies to achieve flexible, smart, and reconfigurable manufacturing processes in order to address a dynamic and global market. The entire product life cycle can be facilitated using various smart sensors, adaptive decision-making models, advanced materials, intelligent devices, and data analytics (Li B et al., 2017). One form of realization of this concept is the IntelligentManufacturing System (IMS), which is considered to be the next-generation manufacturing system that is obtained by adopting new models, new forms, and new methodologies to transform the traditional manufacturing system into a smart system.

In the Industry 4.0 era, an IMS uses Service Oriented Architecture (SOA) via the Internet to provide collaborative, customizable, flexible, and reconfigurable services to end- users, thus enabling a highly integrated humanmachine manufacturing system. AI plays an essential role in an IMS by providing typical features such as learning, reasoning, and acting. With the use of AI technology, human involvement in an IMS can be minimized. (Ray et al., 2017).

4.2. IoT Eabled Manufacturing

IoT-enabled manufacturing refers to an advanced principle in which typical production resources are converted into Smart Manufacturing Objects (SMOs) that are able to sense,interconnect, and interact with each other to automatically and adaptively carry out manufacturing logics (Zhong RY et al., 2012). Within IoT-enabled manufacturing environments, human-to-human, human-to-machine, and machine-to- machine connections are realized for intelligent perception. Therefore, on-demand use and efficient sharing of resources can be enabled by the application of IoT technologies in manufacturing. The IoT is considered to be a modern manufacturing concept under Industry 4.0 and has adopted recent advances, such as cutting-edge information technology (IT) infrastructure for data acquisition and sharing, which greatly influence the performance of a manufacturing system. The real-time data collection and sharing are based on key technologies such as radio frequency identification (RFID)and wireless communication standards. (Ray et al., 2017).

4.3. Cloud Manufacturing

Cloud manufacturing refers to an advanced manufacturing model under the support of cloud computing, the IoT, virtualization, and service-oriented technologies, which transforms manufacturing resources into services that can be comprehensively shared and circulated (Xu X., 2012). It covers the extended whole life cycle of a product, from its design, simulation, manufacturing, testing, and maintenance, and is therefore usually regarded as a parallel, networked, and intelligent manufacturing system (the "manufacturing cloud") where production resources and capacities can be intelligently managed. Thus, on-demand use of manufacturing services can be provided from the manufacturing cloud for all types of end- users (Zhang L et al., 2014). In cloud manufacturing, various production resources and capacities can be intelligently sensed and connected into the cloud. IoT technologies such as RFID and barcodes can be used to automatically manage and control these resources so that they can be digitalized for sharing. Service-oriented technologies and cloud computing are the underpinning supports for this concept. As a result, manufacturing resources and capacities can be virtualized, encapsulated, and circulated into various services that can be accessed, invoked, and implemented. (Ray et al., 2017).

V. CONCLUSION

Product service systems will continue to replace traditional product types. Key concepts, major technologies, and world-wide applications are covered in this paper and mainly focuses on the improvement of Industry 4.0 in a production system, and introduces the common opinions of Industry 4.0 and manufacturing. Summarizing various perspectives, the main concepts of future manufacturing has been identified to inform the research aim. In common with the entire industry, there is a huge gap between recent industry and the achievement of Industry 4.0, which has been clearly identified in this paper. In addition, a framework of Industry 4.0 is presented, which identifies how different intelligence level technologies are acted within three automation of production systems. From the framework, it is obvious that the future of current manufacturing is developing in the direction of Industry 4.0. production successfully challenged by the way of mass production practices to the production systems and focused on good quality products which aimed at customers satisfaction. It can be the answer to a great flexibility of production systems and processes realizing complex products and supplychains. In order to achieve it, it is advisable to introduceIT integration of the production level with the planning level, customers and suppliers by CPS known as "Industry 4.0". focused on the concept of fourth industrial revolution, called Industry 4.0 which allows smart, efficient, effective, individualized and customized production at reasonable cost. With the help of faster computers, smarter machines, smaller sensors, cheaper data storage and transmission could make machines and products smarter to communicate with each and learn from each other. The pillars of industry 4.0 explained to understand the application of Industry 4.0 as well as used to identify the challenges and issues with the implementation of Industry 4.0 for current manufacturing production services.

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