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IFAC PapersOnLine 52-25 (2019) 509–512

Trends in Production Automation

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Abstract: Process – and manufacturing automation as well as robotics are currently one of the fastest growing fields in automation. Cyber-physical systems, industry 4.0 and "advanced robots" are not longer a headline. Production 4.0 is in realization but production 5.0 is knocking on the door. Production 4.5 was introduced one year ago as an immediate step for small and medium enterprises. They are some first dreams on production 6.0.
An important part of production automation is (semi) automated assembly. This topic is currently only outlined in the literature with some description of laboratory tests. Concerning of one of the scopes of TECIS "End of life management – EoL" an important part (semi) automated disassembly is currently missing in all of these concepts. Therefore in this contribution first ideas on (semi) automated disassembly 4.0 including new tasks for "advanced" robots will be given and shortly discussed.
As a consequence of these developments new social, ethical and human questions appear.

Keywords: Manufacturing Automation, Robots, Social aspects, Ethics.

1. INTRODUCTION (Kopacek, 2015)

The main Manufacturing Systems Evolution Drivers are:

- Global growth & competition,
- Knowledge Economy,
- Environmental pressures,
- Molecular manufacture,
- Conflict over resources,
- Ideology, & culture, ICT- ambient & networked,
- Global competition in services,
- Human need,
- Physical Product

A manufacturing process consists of processing operations which transforms a work material from one state of completion to a more advanced state that is closer to the final desired product by means of shaping operations, property enhancing operations, surface processing operations.

Assembly operations joins two or more components to create a new entity, called an assembly by means of permanently (welding, brazing, soldering, and adhesive bonding) or semi-permanently (screws, bolts or rivets, press fitting, and expansion fits).

This yields, in the past, to the development of Computer Integrated Manufacturing (CIM), Intelligent Manufacturing Systems (ims), Agile Manufacturing Systems (AMS). At that time the hard- and software possibilities were very limited and therefore industrial applications of AMS not economic.

Agile manufacturing systems are now realized based on Cyberphysical systems (CPS). CPS comprise smart machines, storage systems and production facilities capable of autonomously exchanging information, triggering actions and controlling each other independently. Based on the new Internet protocol IPv62 introduced in 2012 sufficient addresses are available to enable universal direct networking of smart objects via the Internet. Now is possible to network resources, information, objects and people to create the "Internet of Things and Services".

Environmentally Conscious Manufacturing. Efficient use of materials and natural resources in production, Minimize the negative consequences on the environment (green manufacturing, cleaner production and sustainable manufacturing).

Design for environment (DFE). Select materials that require minimum energy to produce, select processes that minimize waste of materials and energy, design parts that can be recycled or reused, design products that can be readily disassembled to recover the parts, design products that minimize the use of hazardous and toxic materials, give attention to how the product will be disposed of at the end of its useful life.

Smart Factories Beginning to appear and employ a completely new approach to production. Such factories allow to fulfill individual customer requirements. Because of their flexibility last-minute changes in production are possible. The main goal of a smart factory is to produce "lot size One" in an economic way. This yield to a higher number of variants, a high flexible production based on market needs, an "on demand" production, preventive maintenance planning in production, "smart" robots communication

Smart products are uniquely identifiable, may be easily located at all times, know their own history, current status, alternative routes to achieving their target state. (Kopacek, 2018).

Peer review under responsibility of International Federation of Automatic Control.
10.1016/j.ifacol.2019.12.595

2. PRODUCTION 4.0

The Industry 4.0 vision is not limited to automation of a single production facility. It incorporates integration across core functions, from production, materials sourcing, supply chain, and warehousing all the way to sale of the final product. This high level of integration and visibility across business processes will enable greater operational efficiency, responsive manufacturing, and improved product design.

3. PRODUCTION 5.0

We are now in manufacturing automation in the field of Production 4.0 and Production 5.0 is knocking on the door.
Industry 5.0 focuses to validate creativity, high-quality custom-made products and life standard. It aims to increase the life quality of human and not only to increase the technology. It can be called as the fifth revolution of mankind. Smart services are for both communication of humans and non-humans. The communication between humans and non-humans is the sharing of information and data regarding the system. It is important that to design and generate organizations, data-sharing platform and technologies which support the system to interact for the goal.
For Industry 5.0, it is necessary to turn regular machines into safe and self-learning devices to improve their overall performance and maintenance management with the surrounding interaction. Industry 5.0 seeks to build an open and intelligent manufacturing platform for industrial network information applications. The critical requirements of Industry revolution are real-time data monitoring and product location, as well as instructions to control manufacturing.

Industry 5.0 is based on four principles

- Interoperability: The collaboration of machines, tools, and computers in a system.
- Information clarity: The capacity of the sensor-stocked computer systems to create a virtual version of real machines and objects.
- Technical support: Computer systems and artificial intelligence to support workers with strategy, decision making, and work.
- Fragmented decision: The computer systems can complete several and specific task on their own.

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4. ROBOTS IN INDUSTRY 5.0

Cobots will play the primary role in industry 5.0
(a) The machine tending: The robot moves parts for machining inside and outside the machine. While the robot is loading and unloading the workpiece, the operator can do other tasks.
(b) Pick-and-place. The robot moves from the process to the input of another. For instance, it could be grabbed and placed on a tray.
(c) Assembly: (d) Quality tests: the robot loads the products in a quality test machine and takes away them once the test is finished.
(d) Other lightweight weighing applications: The robot performs basic packaging, refining, gluing and other tasks. Evoke that Cobots can do most of the thing's humans do if they do not require great skill.
Most of these applications include tasks without added value (i.e., functions that are not added something about a product that the customer would be ready to pay for). Because it has no added value, the functions are accessible for the Cobots to do and free the man from boring and repetitive work. For the implementation of Cobot, it is best to start small and keep it modest. They can accumulate more complicated applications after you have more experience with Cobots. (Karabegović, P. D. 2018)

5. ASSEMBLY 4.0

Assembly represents the last phase of production processes. Thus, assembly operations manage the whole product differentiation and customization.
Assembly Automation was introduced 1978 with the realization of the first Semi-automatized Assembly Cells (Kopacek, Probst; 1992), (Kopacek, Noe; 1994).
Later the first mostly theoretical papers were published like (Bortolini et.al, 2017)
The robot performs simple tasks when assembling parts that require little skill. (On the same time, assembly tasks that require high skill are perfect for human-robot collaboration: the robot can accomplish the simplest assembly tasks and then move the parts into an area where the man can do the job.

6. DISASSEMBLY 4.0

Disassembly automation came up in 1998 with the realization of the first industrial semi-automatized disassembly cells. (Kopacek, Noe; 1994), (Kopacek, Gschwendtner; 1998), (Kopacek, 2000).
Semi- or fully automatized disassembly especially of electr(on)ic devices was not only because of the standardization by the European Commission (directive on waste from electrical and electronic equipment – WEEE) at that time a hot topic. Usually only the toxic components were

removed manually and the rest of the materials were shred and deposed. Manual disassembly of such devices is today the state of the art. Because of this EC regulation and the increasing amount of electronic scrap manual disassembly get more and more inefficient in the nearest future. Hence automation of the disassembly process was absolutely necessary.
Fig.1 shows all different parts of a modular, flexible disassembly cell. According to the figure the main modules of such a cell are:

- Industrial robots or handling devices with special features like high accuracy, path- and force control (disassembly robot).
- Special gripping devices for a broad spectrum of parts with different geometries and dimensions.
- Disassembly tools especially developed for robots.
- Feeding systems for the products to be disassembled.
- Transport systems – similar as for assembly cells.
- Fixture systems for parts with different geometries and dimensions.
- Manual disassembly stations.
- Intelligent control units able to process information from extended sensors.
- Component database including data of reusable and remanufacturable parts.
- („cost oriented") vision systems for part recognition.
- Various sensors for force and moment limitations, position, distance, etc.
- Storage systems for tools and parts.

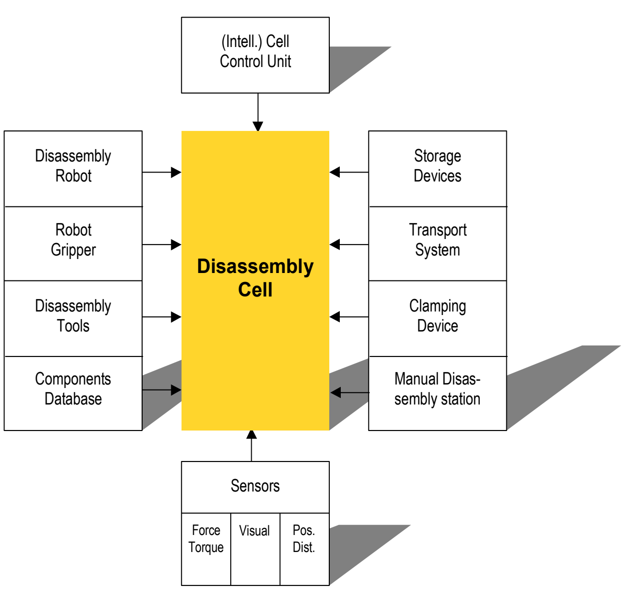

Fig. 1 Modules of an intelligent flexible disassembly cell. (Kopacek P. & B.; 1999)
The differences between semi-automatized assembly and disassembly are: In assembly we can assume that all the parts are new. This is not the case for disassembly because usually the parts could be deformed, corroded …
Otherwise in disassembly we can destroy some parts and fixtures.
Disassembly 4.0 requires new types of robots because they must be able to communicate with other parts and machine tools……….. Furthermore for cracking operations they have to be very robust. This will be the necessary features of Cobots in the future.
These novel disassembly systems are modularly structured as "smart disassembly stations" and "smart part logistic". These system elements communicate and cooperate with each other and with humans in real time, monitoring physical processes and creating a virtual copy of the physical disassembly process to enable quick and decentralized decisions. Beneficial effects are a significant improvement of flexibility and speed of the whole system that enables more customized products, an efficient and scalable production, and a high variance in production control. Finally, proper optimization models, control algorithms, automation technologies and management methods have to be developed to allow the aforementioned smart cyber physical systems of self-optimization, self-configuration, self-diagnosis and intelligent support to workers in their increasingly complex tasks.

7. INFLUENCES FOR TECIS

There are also many hitches stand in the implementation of Industry 4.0

• If the Industry 4.0 is once fully implemented, many uneducated or not educated workers to get jobless.

• To implement Industry 4.0, high skilled factory engineers are needed, so highly educated people are required.

• IT security problems: since Industry 4.0 is highly depended on IT, it is essential to keep the IT security efficiently.

• Fear of IT bugs: There are chances for sudden temporary malfunctions of IT, so many of the essential and confidential processes may get misshapen.

• Reliability problems with the machine to machine communication, still it is not reliable at the level of stability and overall performance according to Industry 4.0 standards.

Shortly, it is expected that advanced detection potential in cyber-human technology will abolish the risk of defects which increases the chances of adoption Industry 4.0 by many companies. Now, many of the participants are agreeing that cyber systems are more reliable than manually operated systems producing exact precision.

The view that the 5.0 industry is a new form of collaboration between humans and robots is to harness the capabilities of machines and people. The machines are more precise and efficient, and the workers have skills, reasoning, and critical thinking. This mode is appropriate for jobs that lie between fully manual and fully automatic manufacturing lines. Working with Cobotics enables companies of all sizes, the implementation of automation and in places where this is not profitable or difficult to implement. This is also due to the rising demand of customers for personalized products that meet their needs and desires.

In general, four key components (CPS, Internet of Things (IoT), Internet of Services and Smart Factory) and six significant technologies artificial intelligence (AI), Big Data, virtual reality, (Internet Industrial of Things (IIoT), CPS, additive manufacturing (3D printing) and collaboration robot (CoBot) and) to advance Industry 4.0. The focus is on the technical aspects of the application. The main thing is human resources exist only in possible changes in the labour market produced by Industry 4.0. This situation is unacceptable and is reflected in several articles related to Industry 4.0. Although Industry 4.0 is only in the early phases of growth and the main achievements cannot be expected before 2020-2025, you can see the image of a new model of Industry 5.0. It means the entrance of artificial intelligence into the common life of man, his "cooperation" with the goal of improving man's ability and man's return to the "centre of the universe." (Vuksanović, Dragan & Vešić, Jelena & Korčok, Davor. 2016)

8.SUMMARY AND FURTHER DEVELOPMENTS

In this paper some trends of production or manufacturing automation, based on previous works, are presented with are or will be in the future of interest for TECIS.

After a short introduction in the fundamentals of Production 4.0 an outlook on further developments – Production 5.0 (6.0) – is given. This subject is currently influenced by a overwhelming digitalization.

According to the scope of TECIS special emphasis is on assembly and disassembly automation 4.0 not only because of the replacement of “low cost” working places which yields to social problems.

On common workplaces because of human – robot collaboration ethical problems arises.

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