DIDACTICS IN I4.0 FLUID POWER SYSTEMS

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In the modern industrial environment, we increasingly encounter the challenges and concepts of the fourth industrial revolution, also known as Industry 4.0, where the main emphasis is on automation, digitization and general integration of all elements of the production process, which represents a drastic change in the way products are produced. Consequently, this rapid progress in technologies also applies to the automation and control of fluid power systems, which presents new challenges in the education system and research work performed at universities, where all new technologies and progress in development have to be studied and explored.

Keywords:
Industry 4.0, research equipment, didactic, fluid power, control

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1 Intruduction

Industry 4.0 has become an increasingly important topic in recent years and represents the so-called fourth industrial revolution. Industry 4.0 is thus a complex technological system that includes a huge number of concepts of new technologies, which are shown in Figure 1. These concepts include cyber-physical systems (CPS), Internet of Things (IoT), Internet of Services (IoS), robotics, computing in the cloud, cognitive computing and augmented reality, which are the result of technological progress in network connections, data analysis, machine learning, universal connectivity of machines and devices, self-diagnostics, etc. All of the above concepts could be presented together with the term "smart factory". It is characterized by the fact that it includes devices, machines, production modules and products that are capable of independent exchange of information, initiation of actions and mutual control. The latter enables an intelligent production environment. [1-3]

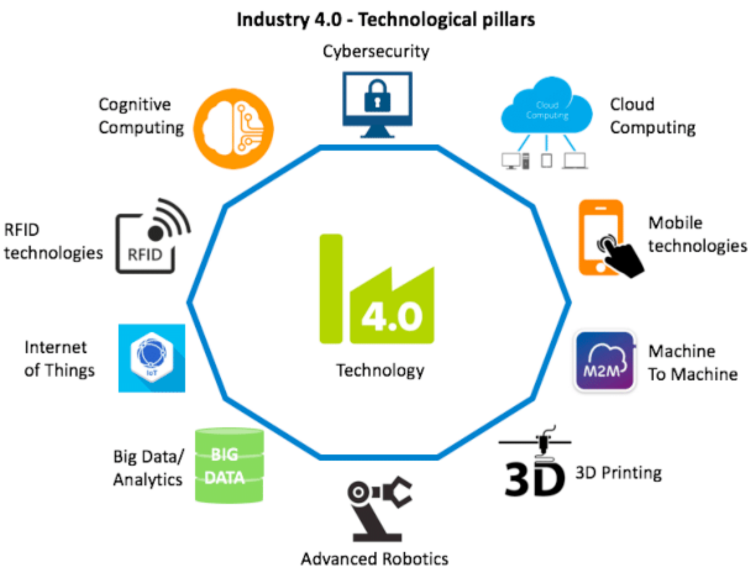

Figure 1: Industry 4.0 core elements [4].

All these key elements and technologies, which are rapidly developing, present a great challenge for the future engineers, as well as for the education system and research work performed at universities, where all new technologies and progress in development have to be studied and explored.

2 Didactics in fluid power automation and Industry 4.0

Didactic systems in fluid power engineering and automation have been increasingly developing in past decades. Basic fluid power system components such as cylinders, valves and simple control systems have been enhanced with modern automation technologies that are part of the I4.0 strategy. Thus, the emphasis is not only on the elemental fluid power elements, but also increasingly on state-of-the-art control technologies and concepts of I4.0.

Figure 2: DLMPS-500C Modular Production System Industry 4.0 [5]**.**

As presented in Figure 2, the market offers various solutions for didactics and research work in the field of fluid power systems, automation and I4.0, from different manufacturers, such as SMC, Lucas Nuelle, Dolang, etc. Their properties and setup mainly vary in complexity and type of used components.

3 Festo CP Lab Cyber physical production system for I4.0

One of the more powerful and sophisticated comprehensive learning and research systems for Industry 4.0 is represented by the Festo CP Lab, which is also available at the University of Maribor. It is a professional and compact cyber-physical system that contains all the components and technologies necessary for in-depth learning and research of digital, fully automated production technologies containing fluid power systems, as well as the design and programming of digital network plants. CP Lab covers complex, software-related I4.0 topics in the field of mechatronics and automation. [6, 7]

CP Lab consists of individual modules, which represent the stations of real production plants. The mentioned modules can be treated as an independent workstation or they can be connected in different layouts using a circular system, which represents production line that transports workpieces between individual processing stations with the help of a conveyor belt. By combining individual modules, we can create different circulation systems that are adapted to different requirements. The system can also be combined with other systems (e.g. CP Factory) or different manipulators. [6, 7]

Figure 3: Festo CP Lab-408-1.
Source: own.

With the described features, CP Lab represents a compact, expandable, flexible and reconfigurable learning and research system for the study of Industry 4.0. Basically, there are four different configurations of CP Labs offered by Festo, each of which consists of different modules or workstations. Configurations differ from each other primarily in terms of the number of modules they consist of. Thus, there are configurations consisting of four, six, eight or ten workstations. At the university, we have the opportunity to work with the CP Lab 408-1 system, which is shown in Figure 3. The system consists of eight workstations that can be changed and adapted to each other. [7]

3.1 Attainable didactic and research activities

The presented CP Lab 408-1 system enables didactic and research work to be performed on core elements and technologies of all levels of modern production systems in I4.0, ranging from low-level fluid power systems and electrical control systems, to higher level Programmable Logic Controllers (PLCs), Human Machine Interfaces (HMI) and SCADAs, all up to Manufacturing Execution System (MES) and Enterprise Resource Planning (ERP) solutions, as presented in Figure 4.

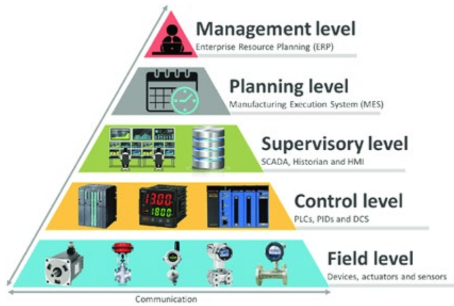

Figure 4: Modern production system organization [8].

Some of the most significant elements and areas of fluid power systems, automation and integration into I4.0 that are included in CP Lab 408-1 system and offer numerous learning and research activities are:

- basic fluid power systems components,
- additional most commonly used equipment in production lines, such as smart sensors, electro-mechanical axes, industrial printers,…
- pneumatical and electrical drawings,
- industrial control technology using different types of PLCs,
- Human Machine Interfaces (HMI),
- identification and object-related data using RFID technology,
- open communication standards between the components,
- modern manufacturing concepts using Manufacturing Execution System (MES),
- system diagnostics and monitoring of operating status and energy consumption,

- smart maintenance based on system monitoring,
- web-based energy monitoring and management,
- augmented reality (new generation HMI with smart glasses).

Additional to above presented key elements, the system also offers complete system simulation in form of a digital twin using CIROS software package, where most of the above technologies can be tested in virtual environment before they are implemented on the real production system.

3.2 Plausible upgrades

Since the CP Lab 408-1 system is built using state-of-the-art industrial components, the system can be easily upgraded with additional technologies. For instance, the “pick-by-light” operation, which is performed manually by the worker, can be upgraded with automated camera vision system that will perform monitoring of assembled work-pieces. Or, secondly, the system can be expanded using a robot that will stack the final production pieces onto a pallet.

4 Conclusion

As we are facing rapid development of technologies related to fluid power systems and especially their automation and control strategies, as a part of integration in Industry 4.0 concept, we are also imposing greater challenges in didactic and research activities performed at universities. As presented in paper, these technologies cannot be considered separately, since all core elements of I4.0 are linked together. In this manner, the CP Lab 408-1 system offers us sophisticated comprehensive learning and research system for Industry 4.0, on basis which new technologies of I4.0 and fluid power systems can be studied and further enhanced for optimal operation and performance.

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