UDC 681.5

MECHATRONICS AS A BASIS FOR CYBER-PHYSICAL SYSTEMS

O. V. Vasylenko, PhD, Assoc.Prof.
National University «Zaporizhzhya Polytechnic»
G. V. Snizhnoi, Dr.Sc. (Eng.), Assoc.Prof.
National University «Zaporizhzhya Polytechnic»
Yu. S. Yamnenko, Dr.Sc. (Eng.), Prof.,
National Technical University of Ukraine «Igor Sikorsky Kyiv Polytechnic Institute»

Keywords: mechatronic systems, Industry 4.0, industrial internet of things, cyber-physical systems, digital platforms, digital twin.

As we know, a mechatronic system is a synergistic combination of mechanics, power and information electronics for coordinated motion in robotic systems. Manipulators, robots, devices of additive technologies (3D printers, for example), even the majority of machines with CNC (Computer Numerical Control), are basically mechatronic systems. Advanced mechatronic systems include intelligent sensors that use Internet of Things (IoT) or Industrial Internet of Things (IIoT) technologies [1] to transmit relevant data to control systems, SCADA, Human-Machine Interfaces (HMI), and other digital platforms. With the transition to the technology of the fourth industrial revolution, the so-called Industry 4.0 (I4.0) [2], these sensors began to send data to create Digital Twin [3], for Machine Learning, for Big Data Analysis for decision-making by means of artificial intelligence and Cloud Services.

Development of CPS models that include mechatronic systems. Digitization of products (cars, household appliances), enterprises, organizations, infrastructure, makes them more autonomous. Influence on these objects of information technologies, in particular the IoT, plus total Automation and use of Model-based Approach turns them into Cyber-Physical Systems (CFS) [4]. We can say that CPS combines the physical and virtual worlds. How mechatronic systems are included in the CFS is shown in Fig.1. Mechatronic systems are depicted at the bottom of the CFS-circle in order to demonstrate their "gravity" to physical worlds (actuators).

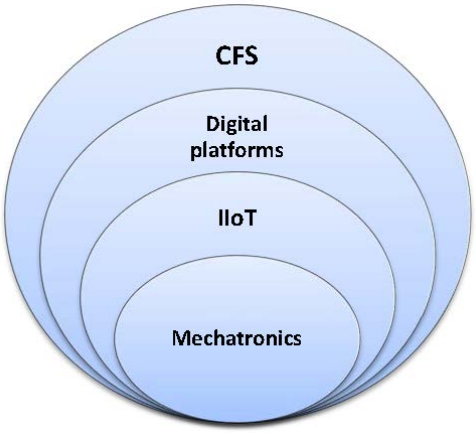

Fig. 1 – Mechatronic systems as a basis for CFS

In CFS, real-world processes occur almost in parallel with virtual-world processes. Sometimes these processes are ahead of each other, for example, in predictive analysis, the virtual CFS model warns of abnormal behavior of the controlled physical object.

Digital manufacture [5], which is a CFS and the main driver of I4.0, is based on robotic systems that are controlled by CAM and CADAM (Computer-aided Manufacturing and Computer-augmented Design and Manufacturing, respectively). Data of processes are sent to SAP – Digital platforms (Systems Applications and Products in Data Processing), which send data to Cloud Services for processing, forecasting, and scheduling. SAP includes specialized application software: EPR – Enterprise resource planning, MES – Manufacturing execution systems, QMS – Quality Management Systems, CRM – Customer Relationship Management), etc.

The model of digital manufacture as CFS with mechatronic has five hierarchical levels. The two lower levels tend to the physical world, and, in fact, to the manufacturing processes, the two upper levels are more relevant to the virtual world, they are used to automate business processes. At the middle (third) level the connection of virtual and physical worlds is carried out by total integration and automation (TIA). TIA portal combines data at all levels and transforms the Plant / Organization / Enterprise into the CFS.

Analysis of modern mechatronic systems and technologies I4.0 showed that mechatronic systems are the basis of cyber-physical systems and provide work with physical assets with data transmission to create a virtual Digital Twin using IIoT technologies. Thus, in mechatronic systems, which are included as basic subsystems of CPS, the role of IT technologies is more significant. The hardware of such mechatronic systems has also changed in order to provide total automation and integration on the basis of the IoT.

References

1. The role of IIoT in Digital Transformation of the manufacturing sector [Online]. Available: https://www.comarch.com/files-com/file_147/White_Paper_Industry_4_0_EN.pdf

2. K.Schwab, The fourth industrial revolution, Geneva Switzerland: World Economic Forum, 2016. [Online]. Available: https://law.unimelb.edu.au/__data/assets/pdf_file/0005/3385454/Schwab-The_Fourth_Industrial_Revolution_Klaus_S.pdf

3. What is Digital Twin Technology and How It Benefits Manufacturing in the Industry 4.0 Era? [Online]. Available: https://slcontrols.com/what-is-digital-twin-technology-and-how-can-it-benefit-manufacturing/

4. Cyber-Physical Systems, [Online]. Available: https://ptolemy.berkeley.edu/projects/cps/

Digital Manufacturing and the Smart Factory in 2021. [Online]. Available: https://www.unleashedsoftware.com/blog/digital-manufacturing-and-the-smart-factory-in-2021