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ELECTROPNEUMATIC AUTOMATION EDUCATIONAL LABORATORY

The article reflects current situation in education regarding mechatronics learning difficulties. Complex of laboratory test benches on electropneumatic automation are considered as a tool in advancing through technical science. Course of laboratory works developed to meet the requirement of efficient and reliable way of practical skills acquisition is regarded the simplest way for students to learn the basics of mechatronics.

The word mechatronics originated in Japan around 1970 to describe the integration of mechanical and electronic components in consumer products. Today it has come to mean multidisciplinary systems engineering and it has never been more important.

The traditional boundaries of classical engineering disciplines have become indistinct following the advent of information technology and computer science. The development of computer science and information technology has broadened the scope of the discipline of electropneumatics giving birth to an interdisciplinary field of engineering as mechatronics. Nowadays, engineering systems, involving a combination of fields, require multidisciplined engineers to be able to maintain efficient systems. Mechatronic engineers and technicians are those who qualified to do so. Their engineering problems are getting harder, broader, and deeper. They are multidisciplinary and require a multidisciplinary engineering systems approach to solve them. Multidisciplinary engineering systems, in addition to the physical system with its sensors and actuators, have as integral parts electronics, computers, and controls. Performance, reliability, low cost, robustness, energy efficiency, and sustainability are absolutely essential.

1. Mechatronics system properties

Mechatronics has become a key to many different products and processes. Modern systems have reached a level of sophistication, which would have been hard to imagine using traditional methods. Mechatronics integrates the classical fields of mechanical engineering, electrical engineering, computer engineering and information technology to establish basic principles for a contemporary engineering design methodology. Mechatronics is the synergistic integration of physical systems, sensors, actuators, electronics, controls, and computers through the design process, from the very start of the design process, thus enabling complex decision making. Integration is the key element in mechatronic design as complexity has been transferred from the mechanical domain to the electronic and computer software domains.

Mechatronics is an evolutionary design development that demands horizontal integration among the various engineering disciplines as well as vertical integration between design and manufacturing. It is the best practice for synthesis by engineers driven by the needs of industry and human beings.

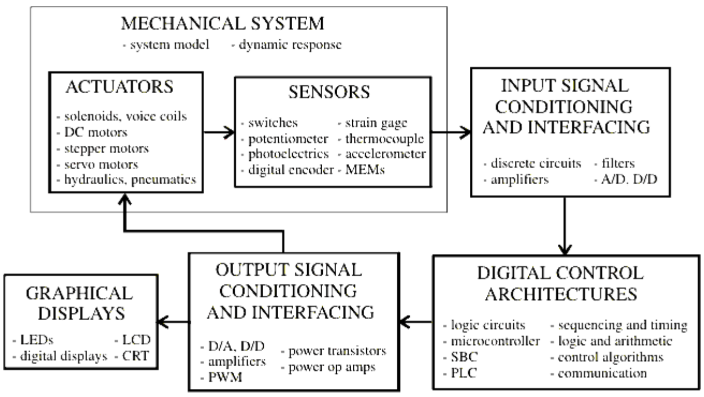

Fig. 1. Mechatronics system components

Mechatronic system design deals with the integrated and optimal design of a physical system, including sensors, actuators, electronic components, and the embedded digital control system. The integration is respect to both hardware components and information processing, both on-line and off-line. In evaluating concepts, a modeling-and-analysis approach must replace any design-build-and-test approach, but this modeling is multidisciplinary and crosses domain boundaries. Every controlled physical system is not a mechatronics system, as controls can be just an add-on in a sequential design process. A real mechatronics approach requires that an optimal choice be made with respect to the realization of the design specifications in the different domains. Mechatronics system design requires simultaneous optimization of the system as a whole.

2. Electropneumatic educational test bench

Engineering education face intimidating challenges. The preparation of new engineers is inadequate for the challenge. Sometimes, it seems that memorization has replaced understanding. Students focus on facts, tests, and grades and fail to understand concepts and processes. They are unable to integrate knowledge, processes, techniques, and tools, both hardware and software, to solve an engineering problem. Indeed, one of the great failures in engineering education has been the inability of graduating students to integrate all they have learned – science, mathematics, engineering fundamentals – in the solution of a real-world engineering problem.

What is the best way to educate students to become practicing engineers?

Only through industrial interaction – knowing the types of problems engineers face, the concepts, processes, and tools they use to solve those problems, and the personal and professional attributes essential to be an engineer leader – not a follower – but an independent-thinking leader in our technological society.

An example of this type of interaction is the complex of educational stands that was created in the department of aviation computer-aided integrated complexes to study fundamentals of computer automation systems on the basis of electropneumatic automation (see Fig. 2).

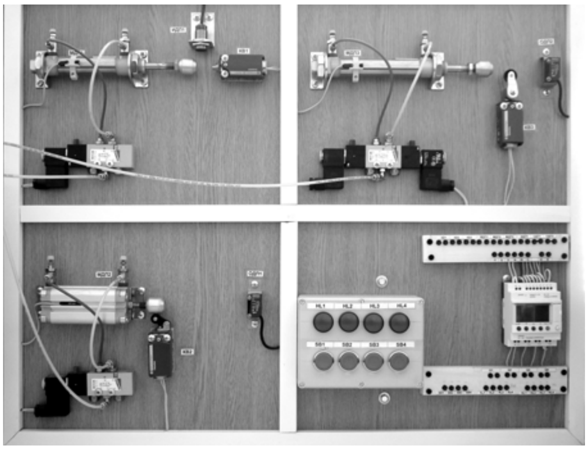

Fig. 2. Laboratory test bench

Educational laboratory on electropneumatic automation combines units of precision mechanics and electronic, electrical and computer components that provide designing of new systems and machines with predictive control of functional movements. Such systems are usually called mechatronics. Predictive control is provided by programmable logic controllers (PLC). A PLC is an example of a real time system since output results must be produced in response to input conditions within a bounded time. PLCs used in educational stands are manufactured by Schneider Electric, industry leader in electrical equipment. Devices have handy control panels, LCD displays and can be programmed directly using available keyset or through the provided PC software.

These test benches are simple and multifunction and allow rather high range of objects to simulate, for instance, conveyor press. Students do not need to mess about meters of wires for successful execution of laboratory work – they need to connect four or five small wires to available input-output board – all other connections are made by PLC according to the program. Simplicity of construction provides higher reliability of the test bench, and even if there will be some failure, the broken device is easy to replace. Important advantage is the application of pneumatic elements which consume less energy, and are much safer than hydraulic ones. Moreover PLCs, optical position sensors used in the laboratory test bench are practically safe because they consume no more than 24 volts DC instead of industrial PLCs, which require more than 120 volts.

Thus, laboratory test bench is safe and energy efficient.

3. Laboratory teaching methods

In order to use the complex of stands with an educational purpose there was developed the course of laboratory works. Laboratory works introduce basics of mechatronics systems construction with the PLC control and electropneumatic devices. There were considered methods of direct and indirect control, pneumatic devices control by speed and position, implementation of logical functions in mechatronics systems, means of real time control using PLC and simultaneous movement of cylinders.

Reasons for using PLCs as the heart of the system are simple. Firstly, less wiring is required to assemble the desired scheme, because wiring between devices and relay contacts are done in the PLC program. Secondly, it is easier and faster to make changes due to programming nature of PLC and available keyset on the front panel. Thirdly, reliable components make these likely to operate years without maintenance before failure.

PLC programs are written in ladder diagram programming language, which is one of the five currently available programming languages for programmable control systems according to international standard IEC 61131-3. Ladder logic diagram programming is a model which emulates electromechanical control panel devices, such as contacts, timers and coils of relays. The actual logic of the control system is established inside the PLC by means of a computer program. This program dictates which output gets energized under which input conditions. Although the program itself appears to be a ladder logic diagram, with switch and relay symbols, there are no actual switch contacts or relay coils operating inside the PLC to create the logical relationships between input and output. These are imaginary contacts and coils. This programming language has an important advantage in educational application – any student is able to understand and use it without much additional training, because of the similarity to familiar hardware systems.

Let us consider abstract from the laboratory work about time control. As an example we consider time delay control using PLC – cylinder rod must remain 5 seconds retracted after releasing the button. The pushbutton SB1 is connected to the smart relay input I1. The timer T1 function block, set for a five second duration, controls output Q1. Output Q1 is connected to the cylinder RH1. The Ladder diagram lines are represented on the Fig. 3.

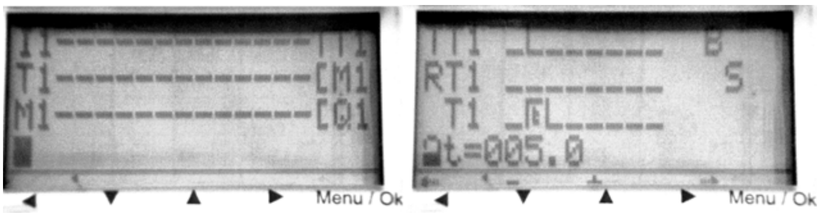

Fig. 3. PLC programming

The schedule of learning curriculum is developed from simple to more complicated. At the start of the course students study methods of direct and indirect control and main principles of ladder diagram programming. And after that they begin to acquire control by velocity, position and simultaneous work of two or more cylinders.

4. FluidSIM Pneumatics training software

FluidSIM Pneumatics is a teaching tool for simulating pneumatics basics. It can be used in combination with the educational laboratory training hardware, but also independently. A major feature of FluidSIM is its close connection with CAD functionality and simulation. FluidSIM allows DIN-compliant drawing of electropneumatic circuit diagrams and can perform realistic simulations of the drawing based on physical models of the components. Simply stated, this eliminates the gap between the drawing of a circuit diagram and the simulation of the related pneumatic system.

The CAD functionality of FluidSIM has been specially designed for fluidity. For example, while drawing, the program will check whether or not certain connections between components are permissible. In FluidSIM each component found in the component library is assigned a physical model. Based on a circuit diagram, FluidSIM takes all relevant separate component models and creates a total model of the system, which is then processed and simulated.

Another feature of FluidSIM results from its well thought-out concept: FluidSIM supports learning, educating, and visualizing pneumatic knowledge. Pneumatic components are explained with textual descriptions, figures, and animations that illustrate underlying working principles; exercises and educational films mediate knowledge about both important circuits and the usage of pneumatic components.

The development of FluidSIM included special emphasis on both an intuitive and easy-to-learn user interface (see Fig. 4). The student will quickly learn to draw and simulate electro-pneumatic circuit diagrams.

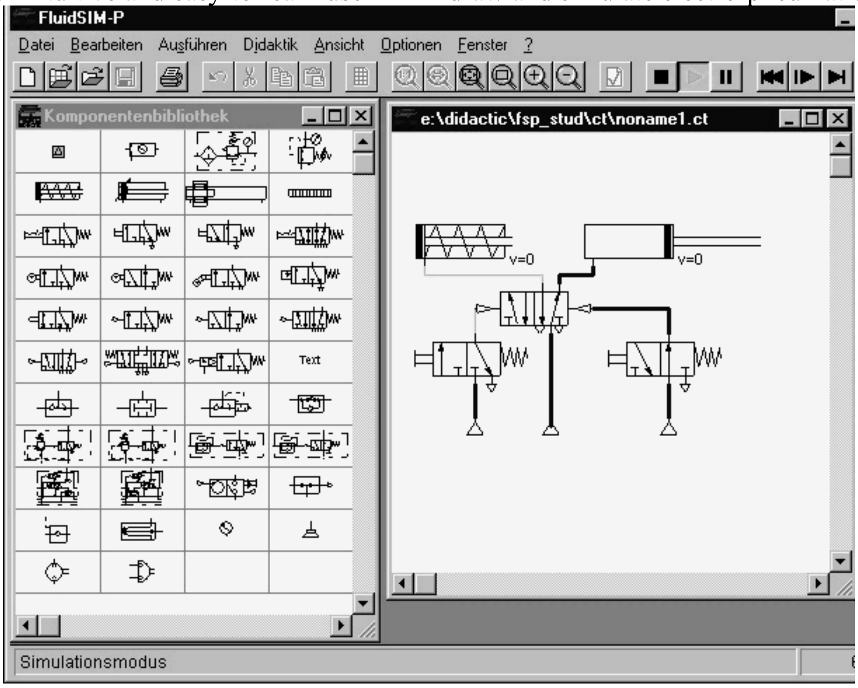

Fig. 4. FluidSIM educational software user interface

Conclusion

Mechatronics is rather new branch of science and technology, which has already come into the professional sphere as well as in our everyday life. Domestic machines, transmissions of new cars, digital cameras and computer disk drives are based on mechatronics principles. Pneumatic devices are widely used in aviation. Electropneumatic drives are used to solve many tasks of various levels of complexity, such as landing gear drive system in training aircrafts Yak-18T, Yak-52, etc. Electropneumatic automation with embedded microprocessor control is where the innovations come from. The importance of mechatronics will further increase due to consumer demands, which will yield excellent job opportunities for skilled workers, technicians and engineers.

Basic engineering skills have become commodities worldwide. Other countries have a competitive advantage in low-cost manufacturing and services, with excellent engineers available at one-fifth of the cost of an engineer with advanced skills and progressive mind. To be competitive, engineers must provide high value by being immediate, innovative, integrative, conceptual, and multidisciplinary. It is generally agreed that engineers must have depth in a specific engineering discipline, as well as multidisciplinary engineering breadth, with a balance between theory and practice. In addition, they must have breadth in business and human values.

Real-world engineering problems, i.e., mechatronic system design problems, present enormous challenges to both education system and industry. Engineering education is in crisis, both at the university and professionally. A radical change is needed. Nothing less than dramatic changes will do.

References

1. *K. Craig,* “Mechatronics in University and Professional Education: Is There Anything Really New Here?”,2001, IEEE Education Special Issue of the Journal of Robotics and Automation, Vol. 8, No. 2, pp. 12-19.

2. *K.* Craig *and F. Stolfi,*“Teaching Control System Design through Mechatronics,” 2002, Mechatronics, Vol. 12, pp. 371-381.

3. *Tony R. Kuphaldt*, “Lessons In Electric Circuits, Volume IV,” fourth edition, 2007.

4. *Prof. Dr.-Ing. Johannes Steinbrunn*, “Curriculum for Mechatronics”, Festo Didactic GmbH, 2005.

D. Waller, H. Werner, “Learning System for Automation and Technology. Electropneumatics workbook”, Festo Didactic GmbH, 2002.

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