Acta Mechatronica - International Scientific Journal about Mechatronics
Volume: 9 2024 Issue: 4 Pages: 39-42 ISSN 2453-7306

https://doi.org/doi:10.22306/am.v9i4.130

Received: 09 Nov. 2024
Revised: 05 Dec. 2024
Accepted: 16 Dec. 2024

Educational procedures for training students in the field of pneumatic systems

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Keywords: pneumatic systems, educational procedures, methodology, laboratory equipment.

Abstract: The aim of this article is to present an educational model of the process of teaching students in subjects focused on the use of compressed air in automated industrial operations. The starting point is the existing commercially available training platform kit, the use of which provided the basis for developing the student training model described in the article. The article further discusses the training needs in all methods of controlling pneumatic circuits and focuses on the possibility of building an independent training workplace based on the electropneumatic base of the components used. The article describes several stages of the constantly improved educational platform, also with the contribution of student involvement in this activity. The conclusions of the article offer further guidance in the gradual completion of the educational model focused mainly on the practical training of graduates resulting in the ability to respond to market challenges after completing their university studies at our faculty.

1 Introduction

The operations of current companies operate at various levels of automation, therefore they increasingly require well-founded and professionally trained personnel for operation, maintenance, and possibly also for the design or construction of automated equipment. Production automation is still massively based on the use of components using compressed air as an energy or signal source. Therefore, forms of personnel training are increasingly oriented towards methods of training in the field of compressed air. This trend is also followed by the currently strongly preferred form of dual education in secondary schools. Theoretical mastery of the issue is beginning to appear insufficient for the direct deployment of graduates of technical schools into practice. The only viable path is education in the form of laboratory exercises and practical training of routine activities of future technicians in automated operations.

However, there is no need to tell yourself that technical higher education does not have to follow this trend.

1.1 Basis for the educational training model

The need for practical training of our students led us to gradually build laboratory spaces supporting the training of practical skills needed in practice.

These skills consist of the graduates' ability to respond to problems that may arise in operation (whether as malfunctions or signs of progressive wear and tear) and the ability to solve or eliminate these problems by directly intervening in the system.

An important aspect of our intentions was to prepare our graduates on technical equipment built on real components identical to those used in technical practice.

The starting point was the purchase of training tables with the designation PNEUTRAINER Pneu 200 from SMC Corp. (Japan), Figure 1.

Figure 1 PNEUTRAINER 200. Sources: left: [3]; right: author's archive

The disadvantage of this system for practicing practical skills in connecting pneumatic circuits is the fact that it allows work only in the mechanical, manual and pneumatic control modes. This method of using the system is based on the method of controlling the valves used in the kit, Figure 2.

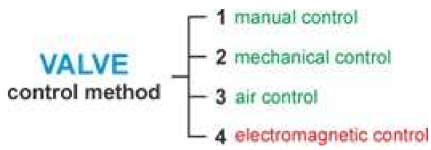

Figure 2 Valve control methods

The method of implementing the education of our students was initially designed as a reduced one and represented only the connection of circuits, which can be solved by the three mentioned methods of controlling the valves used (methods 1 - 3; Figure 2).

2 Methodology

For this method of applying education, some methodological procedures have been developed that should help the student more quickly orientate himself in the issue of using the potential of the building kit used.

Despite the incompleteness of the possibilities to cover the entire spectrum of control elements used in pneumatic systems, the described methodology (after mastering pneumatic symbols and practicing "reading" pneumatic diagrams by students) provides the following possibilities:

1. ***Connecting a pneumatic circuit according to the wiring diagram.*** Students have a total of 40 wiring diagrams of varying difficulty available and have the opportunity to try each one. In the overall evaluation of some courses, this procedure is also used for partial evaluation of the student (the student draws a connection scheme number and is evaluated based on the submitted performance during its connection). Of course, before connecting the relevant wiring diagram, the student must demonstrate his knowledge by “reading” the diagram in front of the teacher (describing what will happen after connecting and activating the circuit).
2. ***Drawing a circuit diagram of a circuit connected by the teacher.*** The students are tasked with drawing a circuit diagram of a circuit prepared (connected) by the teacher. The drawn circuit diagram is compared with the existing diagram by the teacher.
3. ***Finding and eliminating faults in the circuit.*** Students are given a connected circuit and a corresponding wiring diagram. The instructor intentionally “introduces” several anomalies into the circuit, which lead to the circuit not functioning. After reading the wiring diagram, the student has the task of finding out what the circuit is supposed to do and, based on the incorrect manifestations of the “faulty” circuit, eliminating individual shortcomings in the wiring.

This training model has proven its worth in practice, and its suitability has been confirmed by the satisfaction of the participants from practice who attended our training courses.

A simple "navigation" system for searching for the necessary components in the kit was used with a positive response from students, Figure 3.

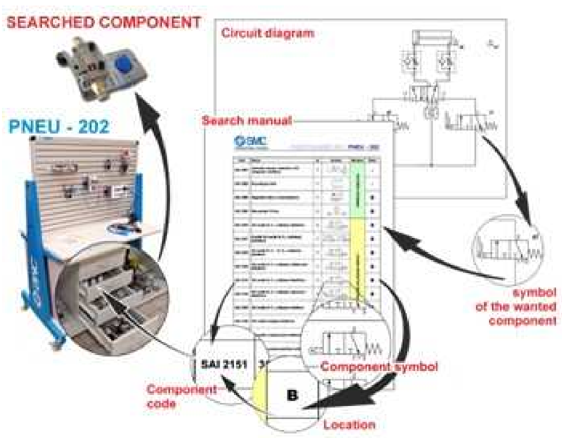

Figure 3 Methodological model for component search

In parallel, a series of lectures is being held in the described model, containing the theoretical basis necessary for understanding the connections valid for the pneumatic circuit. These lectures are supplemented with demonstrations of representatives of individual categories of pneumatic components.

During the implementation of this model, it was discovered that the practice also requires training in the use of electro-pneumatic components for its needs. For this purpose, the existing set and its methodological training model were unusable.

Two options were considered in the search for a solution:

1. Purchase electro-pneumatic components and the control superstructure of the existing kit from the supplier of the basic kit (ultimately, this solution was rejected due to the amount of necessary initial investments).
2. Develop a separate model training workplace that would offer even greater freedom in implementing student training.

Option 2 was accepted as feasible and was developed as part of the diploma project of a student at our institute [1], Figure 4.

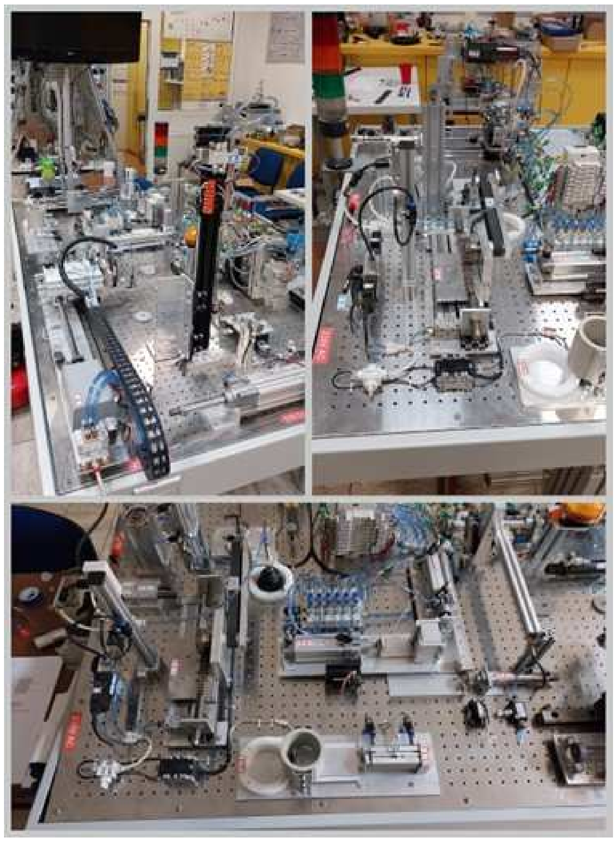

Figure 4 Training table for electro-pneumatics teaching

The workstation (trainer) provides opportunities to understand the methods of controlling pneumatic circuits solved by electropneumatic control of control elements (monostable and bistable electropneumatic valves organized in the form of valve islands: a total of 7 valve islands with different numbers of valves used - max. 8 valves in combination of 5/2 bistable and 5/3 valves with a closed center position) with actuators whose extreme positions are provided with appropriate sensor equipment (electronic/reed magnetic sensors, mechanical microswitches, diffusion sensors).

A simple binary operating control unit (SIEMENS LOGO!), Figure 5, is available, enabling the solution of assigned tasks in controlling the activities of a total of 12 separate workplaces with varying degrees of difficulty (from simple movement between the extreme positions of one drive, through the solution of sequential movements of a pair of drives to the solution of movements of an electro-pneumatic mechanism).

Figure 5 SIEMENS LOGO! PLC modified for use on a trainer

The control unit is designed to be ready for changing the controlled mechanism so that individual inputs and outputs are solved via connector fields (3-pin for input signals from sensors, 2-pin for outputs). In addition to simpler configuration of inputs/outputs for new tasks, they prevent the control unit (PLC) from being damaged by repeatedly screwing the wires providing the input and output signals needed for a specific task on the unit's terminal block.

Students in practical seminars also have the opportunity to solve the assigned task in the form of a design proposal with its physical implementation, Figure 6.

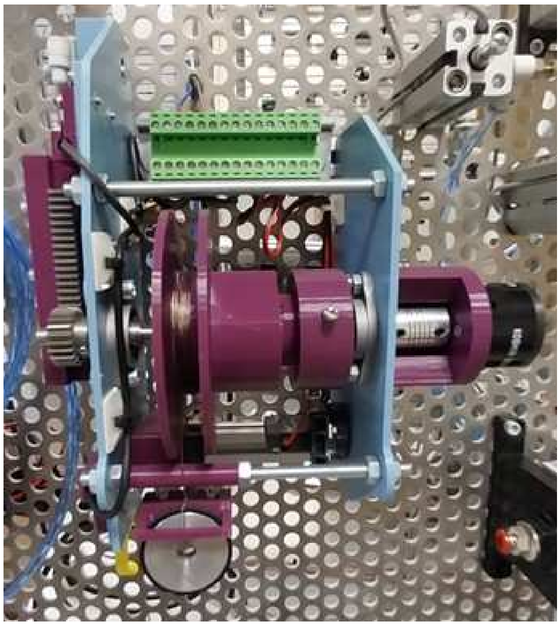

Figure 6 Pneumatic winch mechanism

Figure 6 shows a winch mechanism equipped with a single-acting pneumatic drive, operating on the principle of a free-wheel bearing and a rack-pinion transformation pair as the output of solving a task by students of our department within the subject Teamwork.

The entire educational model was tested as part of the teaching for its suitability for off-line use and therefore its suitability for application in the form of e-learning [2], Figure 7.

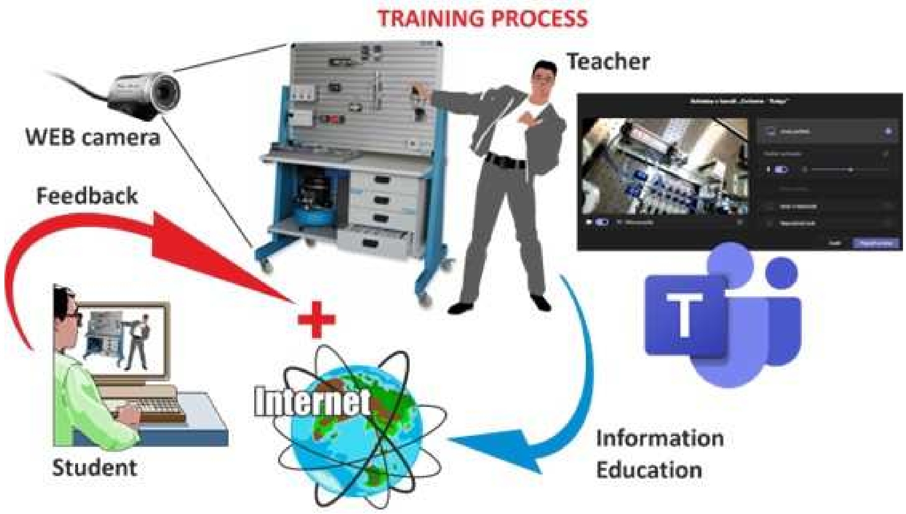

Figure 7 Model of incorporating a methodological model into an e-learning form of training

Volume: 9 2024 Issue: 4 Pages: 39-42 ISSN 2453-7306

3 Results and discussion

The described educational model is in constant development, but the current state fully meets the needs of teaching at our workplace. The solution in the described setting was positively received by students and many praised the opportunity to solve some tasks in a practical form. We also received a positive response after completing the training of operators and maintenance of several companies operating in the Košice area.

Currently, the system for training in the field of electropneumatics is being upgraded to a higher version of PLC control (the original LOGO! PLC in version 0BA6 is being replaced with the latest version LOGO! 8.4), Figure 8.

Figure 8 PLC control unit with expansion module in SIEMENS LOGO! v. 8.4 version

This will increase the possibility of integrated control from one central PC at multiple workstations within the laboratory. This will significantly expand the possibilities of using the current potential of the laboratory's equipment.

4 Conclusions

Practical experience with the use of the described educational model has not only revitalized the teaching process, but also increased interest in information regarding the use of pneumatic systems in technical practice.

There is also feedback regarding successfully defended bachelor's and master's theses, as well as other projects (the AVENTICS/EMERSON Pneumobile project) in which our students have been and are involved.

We believe that with the above-mentioned reconstruction we will reach an even higher level and, above all, the compaction of the hitherto considerably non-compact system into a connected whole with significantly higher possibilities of use.

Acknowledgement
The contribution was created within the framework of the KEGA project 1/0215/23 Research and development of robotic workplaces equipped with industrial and collaborative robots.

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Review process
Single-blind peer review process.