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LABORATORY FOR AUTOMATION AND MEASUREMENT AT THE UNIVERSITY OF MONTENEGRO

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ABSTRACT
The Faculty of Mechanical Engineering at the University of Montenegro has established the Laboratory for Automation and Measurement, covering the field of pneumatics, hydraulics and electronics. In order to provide practical-oriented education in these areas, the laboratory is absolutely necessary. As a contribution to this, the basic equipment for this laboratory, in this paper, we will describe and highlight preliminary ideas for the effective management of the laboratory and its future development.
Keywords: Automation, pneumatics, electro-pneumatics, electronics, laboratory.

1 INTRODUCTION

Our students need particular laboratory equipment in order to acquire and apply appropriate technical know-how. "Learning by doing" is an effective learning method which requires a laboratory environment where theories are practically applied. In this light, the Faculty of Mechanical Engineering established and equipped modern Laboratory for automation and measurement.
In the Laboratory, the topics from lectures are further elaborated, and step by step, students are guided towards more complex sets of experiments, like configuration components and technological processes management. Experiments are divided into the following units:

- Basics of Electrical Engineering/Electronics,
- Basics of Pneumatics and Electro-pneumatics,
- Basics of Hydraulics and Electro-hydraulics,
- Measurement techniques applied in Pneumatics and Hydraulics,
- PC applications.

The experiments are planned in such a manner so that they can include working tables with electrical/electronic, pneumatic, electro-pneumatic components, electric and pneumatic actuators, sensors, electro-pneumatic three axes servo drive, hydraulic and electro-hydraulic components, together with PLC applications.
One of the main goals while choosing the laboratory equipment was the connexion between education and research. Majority of the laboratory equipment is in accordance to industrial standards and can be used for industry-oriented education and research in the form of project and diploma papers and master theses.

2 EQUIPMENT

Equipment for the Laboratory was procured through several international and national projects, together with the support of domestic donors and the funds of the Faculty of Mechanical Engineering in Podgorica. Today, the Laboratory contains the following equipment:

2.1. Laboratory system for basic and advanced pneumatics and electro-pneumatics

Completely new industrial components enable students to learn new industrial standards.

The most important system components for the basic pneumatics and electro-pneumatics are: 3/2 and 5/2 pneumatic control valves, 3/2 and 5/2 solenoid control valves, 5/2-valve with selection switch, pneumatic proximity switch with a slider for cylinder, pneumatic timer, AND and OR valves, quick exhaust valves, one-way flow control valves, valve - pressure regulator with manometer, manometer, manifold, input electrical signals unit, relay, electric limit switch, proximity sensors (electronic and optical), pressure sensors, flow valves, etc.
The system will be used for training and research for the following fields: structure, function, one-way and two-way cylinder application, calculation of basic parameters and direct and indirect activation of cylinders, application and functions of 3/2 and 5/2 pneumatic and solenoid valves, logical operations: AND/OR/NO/XOR, combination and sequential logical circuits, (synthesis and analysis), function and application of limit switches, time delay valves, sensors and sensor technology, supervision of the final position by using the proximity sensor, pressure measurement, pneumatics-electrics interface, removal of problems in the simple electro-pneumatic circuits.
The system for advances pneumatics and electro-pneumatics presents an upgrade of the previous system. Apart from additional cylinders, valves, and different types of pneumatically, mechanically and magnetically activated control valves, the most important components are: pneumatic timer and gauge, step module, input electrical signals unit, relays and time relays, electrical incremental gauges, inductive and capacitive proximity sensors, valve terminal for four valves, delockable non-return valves, etc.
The system for advances pneumatics and electro-pneumatics enables training for: binary reduction of phases, final positions without limit switches, latching circuits, basic stepping drive (continuous cycle), counter-pressure and stopping functions, stepping drive with working mode or inactive step, setup and coordination of time delay, repetition of changeable step by using the previously defined gauge, input circuits with self-connecting loop and additional functions, use of sensors for material detection, realisation of step drive, proximity sensor for final positions and within the range of partial positions, combined use of quick exhaust valves and pressure regulators, inversion of a time signal, use and setup of different sensor types, description of structure and application of valve terminals, realisation of sequential drive with overlapping signals – sequential chain with valves with springs and sequential chain with bistable valves, description of function and application a predetermined gauge, function “emergency-off“ with the use of spring valve, definition of conditions for “emergency-off“, function and applications of 5/3 solenoid valves, description and setup of a work mode “*set*“, removal of faults and errors in complex electro-pneumatic circuits, etc.
All of these components can be easily installed on aluminium profile plate in order to make it ergonomic. The plate is installed into a mountable frame on a mobile trolley for better mobility. Furthermore, all the components can work independently and in the system and can be combined into different configurations.
Synthesis and analysis of pneumatic and electro-pneumatic drive circuits is supported by software FluidSIM-P, which can be used for experimenting, provision of realistic simulation in real-time, lesson preparations. Additionally, it can be used for virtual modular drive system and can be integrated into an excellent learning concept. The software contains integrated slides of basic circuits, animation of how particular components work, teaching points, support for a huge number of Windows compatible images and multimedia forms, integrated basics for pneumatics, etc. (Version of the software for hydraulics FluidSIM-H offers similar possibilities).

2.2. Sensors in pneumatic drive systems

Equipment for basic measuring in pneumatics contains 3 sensors for pressure with indicators, 1 flow sensor with display, software **Fluid Lab®-P**, 1 U/I cable with SysLink connectors on both sides, 1 universal digital (SysLink) connexion unit, 1 analogue connexion unit, 1 PC cable RS232, 1 analogue U/I cable, 1 EasyPort DA.
Set of sensors for object detection consists of:, 8 proximity sensors of different working modes and types (magnetic, inductive, optical, capacitive proximity switches and inductive sensors (analogue), 2 one-way optical barriers (1 transmitter and 1 receiver), 1 capacitive proximity switch, 1 infrared optical barrier, 1 switch, 1 reflecting unit for reflectional light barrier, 3 optical fibres, 1 set of test elements, 1 location indicator, 1 functional generator/gauge/stopwatch, 1 distribution unit, 1 rotation unit.

Measuring set for distance and displacement consists of: 5 sensors for distance and moving of different types, 1 set of complete test objects, 1 location indicator, 1 set of weights, 1 controller for motor, 1 analogue connexion unit, 1 signal switch unit, 1 linear potentiometer, 1 verier measurement instrument, 1 working unit with spindles, 1 drive engine, 1 direction switch leverage.
Measuring set for force and pressure consists of: 2 different analogue pressure sensors, 1 pressure switch, pneumatic-electrical converter, 1 force sensor, 1 sensor for direction switch leverage, returnable pressure switch, 1 set of weights, 1 set of disc-shaped weights, 1 distribution unit, amplifier - measuring bridge, 1 analogue connexion unit, 1 signal switch unit, 1 start switch with filter drive valve, 2 pressure manifolds, 1 reservoir for pressurised air, 1 cylinder, 1 valve with a key button, 1 one-way valve for flow regulation, 10 m of plastic pipes.
The purpose of measuring technology is configuration, function of areas of application and the selection of sensors is based on the requirements of an application. Practical experience plays a key role in the teaching process. Application examples are used to demonstrate general working principles of different types of sensors. Particular attention is drawn to choosing the right sensor, connexion of the sensor, correct setup, and functional check.

2.3. Pneumatic positioning with the SPC 200 axis controller

Figure 1a, b, c: Laboratory for automation and measurements.

Equipment set for the setup and commissioning of single and multi-axis pneumatic positioning systems or gantry systems is in connexion with the SPC 200 axis controller.
Teaching targets are: set up and commissioning of multi-axis pneumatic positioning systems, mechanical and electrical set up of a two-axis gantry system, using digital technology to realise powerful servopneumatic drive control circuits, programming multi-axis positioning systems, assembling and commissioning a gripper, programming and implementing handling tasks, analysing and optimising control response, visualising and assessing motion response, troubleshooting NC axes, emergency-off circuits for NC axes.
Training targets: setup and work with pneumatic NC axes, realisation of a complete drive control circuit for servopneumatic drive using digital technology, mechanical and electro setup of the axial system, programming of numerically driven axes according to DIN 66025, installation and placement of the grippers, programming and implementing handling tasks, analysing and optimising control response, visualising and assessing motion response, troubleshooting NC axes.
Equipment set for the setup and commissioning of single and multi-axis pneumatic positioning systems or gantry systems is in connexion with the SPC 200 axis controller.
The SPC 200 is a position controller for pneumatic axes. The main features are: optimized for 2 axes, expandable up to 4 axes with subcontroller, quick installation of valve and measuring system via axis interface, modular system, simple operation and programming via control unit, convenient programming with WinPISA software, link to higher-order controller via freely programmable inputs and outputs.

2.4. Laboratory system for hydraulics and electro-hydraulics
Learning and training targets regarding equipment for hydraulics and electro-hydraulics (for the basic knowledge level) are: learning about valves and devices and their function; learning about electrical components; function and application of various valves and devices; measuring variables such as pressure, flow and time, calculating surface ratio, force, output and speed; physical fundamentals of hydraulics; applying basic hydraulic equations; using symbols according to DIN/ISO 1219; drawing displacement-step diagrams; drawing electrical and hydraulic circuits; constructing and

commissioning control systems, including troubleshooting; basic hydraulic circuits such as pressure sequence circuits, pump bypasses, differential circuits, feed and return circuits, bypass circuits, counter pressure and bypasses using a non-return valve.
The most important components are: 4/2-way hand lever valve, 4/3-way hand lever valve with recirculating mid-position, pressure relief valve/pressure sequence valve, pressure relief valve - piloted, 3-way pressure reducing valve, 2-way flow control valves, non-return valve - delockable, diaphragm accumulator with shut-off block, hydraulic motor, double-acting cylinders, 16/10/200, weight, non-return valves, flow control valve, one-way flow control valves, shut-off valve, branch tee, pressure gauge, signal input - electrical, indicator unit and distributor - electrical, relay - three-fold; limit switch - electrical, left-actuated; limit switch - electrical, right-actuated; 4/2-way solenoid valve; 4/3-way solenoid valve with closed mid-position; non-return valve, delockable, hydraulic motor, Non-return valve, pressure gauge, weight. Hydraulics measurement set contains 1 flow measurement device, 1 sensor for pressures ranging from 0 to 100 bars, 1 sensor for temperatures ranging from 0 to 100 °C, 1 USD cable, 2 measurement lines, 1 universal display.

3. ORGANISATION FOR EFFECTIVE AND ACTIVE LEARNING

Some of the elements of the Laboratory class organisation are:
- Training materials for all systems and components (teaching materials, CD or DVD – both for students and teachers ...) are also translated into English, and we plan to prepare them for the Serbian language as well.
- Attendance to preparation and laboratory exercises is obligatory.
- Close connexion between lectures and laboratory activities.
- Preparation of tasks which should be completed according to instructions in order to prevent wasting of time.
- Support for students in the Laboratory from the people who know how to solve the problems.
- We plan to provide data on components and courses in paper form in the Laboratory and on the internet site as well.
- Teachers are required to give clear tasks that a student should solve.
- In the Laboratory there is a big whiteboard which may be used for presentations and further discussions about interesting topics.

4. CONCLUSION AND PERSPECTIVES

Use of basic laboratory equipment for the particular subjects is an integral part of the curricula for BSc and Master Degree at the Faculty of Mechanical Engineering. Special emphasis is put onto industrial components, modularity and training materials both for the students and the professors. Apart from that, the equipment can be used for industry-oriented research. The equipment of the Laboratory for automation and measurement was provided through several phases, through two projects financed by WUS-Austria, through one big national project, and through several donors from Montenegro as well.
We formed the Didactics Centre within the Laboratory, which will, after an appropriate instructors training, enable having courses and trainings for interested groups including there both employed and unemployed population.
Provision of equipment for the Laboratory in not yet finished. It is a continuous process, depending on funds, mainly obtained through different projects, mostly international ones. We are currently in Tempus project, where The Faculty of Mechanical Engineering and the University of Montenegro are partners, and the project will enable the provision of the laboratory equipment for mechatronics as well. Additionally, we are considering the possibilities for funding the provision of compact system for process automation. The equipment would be useful for training of both student and course takers within the Didactics Centre, taking into consideration the condition and the profile of the Montenegrin economy as well.

5. REFERENCES

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