20th International Conference
ENGINEERING MECHANICS 2014
Svratka, Czech Republic, 12 – 15 May 2014

INNOVATIVE MODULAR PNEUMATIC VALVE TERMINAL WITH SELF-DIAGNOSIS, CONTROL AND NETWORK COMMUNICATIONS

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Abstract: *The main objective of our research project was to design an innovative modular pneumatic valve terminal with self-diagnosis, control system and industrial network communications for process control, in which for safety or sensitivity reasons of the process is required to confirm switching the valves. Valve terminal with an integrated electronic system allows, depending on the type of device confirmation of function of the valves, control of the valves, control of the logic states, pressure measurement, valves diagnostics. Depending on demand will be available three types of the valve terminal: basic, control and diagnostic. Diagnostic type of valve terminal integrates the functions of two previous types valve terminal and expands the functions about self-diagnosis and troubleshooting.*

Keywords: Pneumatic valve terminal, Self-diagnosis, Directional pneumatic valve, Energy saving systems.

1. Introduction

Currently, there is Directive of the European Parliament and Council called machinery directive and safety standards harmonized with the Machinery Directive type A, B, B2, C for companies involved the design and / or producing and / or marketing of commercial machines. Adapting to these requirements is now an integral part of the activity of each legal entity engaged in the machines within the European Economic Area (EU Member States plus Norway, Iceland, Liechtenstein and Switzerland). There are requirements that must be met by the machine, their failure is associated with the possibility to hold accountable (Directive on the liability for defective products 85/374/EEC and Directive 1999/34/EC amending it). The reason why the market partners (employers, insurance companies, administration, technical supervision) are interested in applying the provisions of the Directives, is the expectation to meet the requirements for products, enabling fair competition when placing products to trading on the single European market (which is an essential part of enabling free movement of goods) and the safety of users.

The development of automation and robotics has contributed to an increased interest in electro-pneumatic servo-drives, which are highly dynamic, reliable, and cheap to manufacture. However, their application to industrial robots and manipulators is limited due to unsatisfactory positioning accuracy, with this problem being difficult to solve in the case of pneumatic systems (Takosoglu et al., 2009; Takosoglu and Laski, 2011; Takosoglu et al., 2012). Therefore pneumatic directional control valves are widely and commonly used on production lines in simple automation systems. Function of pneumatic directional control valves is separation the compressed air stream between the flow surfaces of the outputs (Gerc, 1973; Szenajch, 1997). Such constructions do not return information specifying the position of the piston in the valve, and thus does not possibility of diagnosis failure of the valve and drive. The systems used to control the fluid drives do not have direct safety circuits confirming switching the valve. In the fluid systems should be the following safety features: off under pressure, reducing pressure and force, venting, speed limit, movement

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without danger, stopping, holding and blocking the action, reversing the direction of movement, protection against unexpected starting.

2. Design of Pneumatic Valve Terminal

Designed valve terminals will be equipped with components which provide:

Status checks of controls elements:

- confirmation of switching the valves,
- reading logic states of IO modules,
- parameters measurement of controlled elements.

Control of driving systems:

- switching the valves
- change the logic states.

Diagnostics of processes and valves:

- parameters checking,
- errors indication,
- valve diagnostics,
- diagnostics of selected states of the process.

All available functions of pneumatic valve terminal operate in real time (Blasiak et al., 2013). Fig. 1 shows the module of pneumatic control valve in cross section.

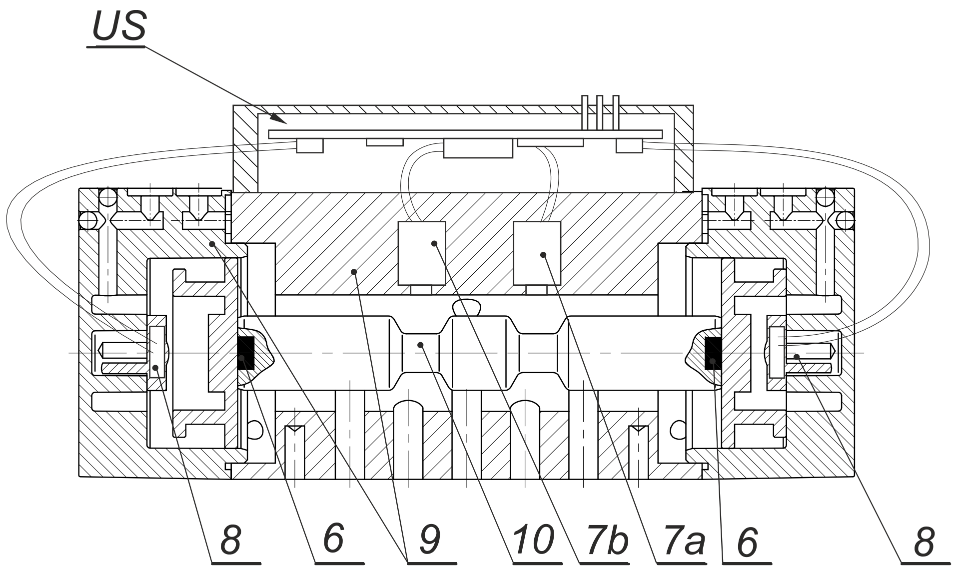

Fig. 1: Cross section of pneumatic control valve: US – control system, 6 – permanent magnets, 8 – magnetic sensors, 9 – valve body, 10 – valve piston.

Due to industrial demand, valve terminals will be characterized by a modular structure. This allows to apply the device to the proper process. The designed device will consist of the following electronic modules:

- main controller module,
- communication module,
- dedicated modules of pneumatic valves,
- universal IO modules,
- universal AI AO modules,
- DC motors modules and servo drives modules.

Fig. 2 shows a schematic diagram of the control system of the double acting pneumatic cylinder by using of the proposed innovative modular pneumatic valve terminals with self-diagnosis, control and communications network.

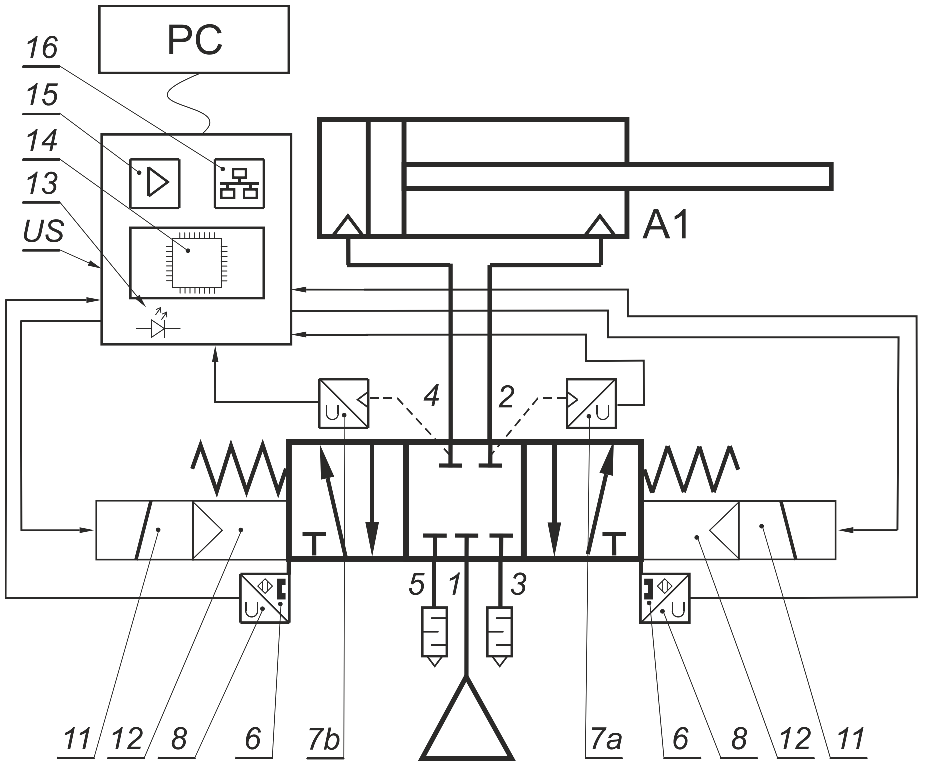

Fig. 2: Schematic diagram of the control system of pneumatic cylinder.

In the body 9 of the valve are flow ways 1, 2, 3, 4, 5, and a piston 10, where on ends, are mounted permanent magnets 6. In the body 9 are a pressure sensors 7a, 7b placed in the chamber, which space is connected to the outputs 2 and 4 of the valve. The pressure sensors are connected to the AD transducer of the US control system. The coil 11 controls the pre-valve 12. After applying the voltage to the coil 11, the pre-valve is switched and compressed air moves the piston valve 10 to one of the end positions. Moving the piston causing opening the flow surface and air flow to the one of the two outputs (2 or 4), depending on the position (left or right) of the piston 10. The magnetic sensors 8 detect the position of the permanent magnets 6 installed on the ends of the piston 10. This is confirmed the position of the piston valve, and is the equivalent to total valve switching. In outputs 2 and 4 by means of sensors 7a and 7b is mesured pressure. The pressure measurement and confirmation of the end positions of the piston 10 carries out self-diagnostics, safety features, and self-monitoring of the control valve. The control system US contains a microcontroller equipped with AD transducers and connected to amplifiers. To the AD transducers are connected magnetic sensors 8, and pressure sensors 7a, 7b. Amplifiers 15 are connected to the coils 11 of the pre-valve 12. The microcontroller 14 is connected to the network communication module 16, and optical indicator LED 13. The program code of the microcontroller can be written in the Matlab-Simulink (Gapinski et al., 2013). US control system with microcontroller 14 is used to control, pressure monitoring, monitoring end positions of the piston valve, safety features, save to SD card, monitoring process states and performs the functions of self-diagnosis. By means of diagnostics can be detected errors and failures in the operation of the valves.

In addition, diagnosis can be done also for driving systems by installing the position sensors on actuators. The control system has a network communication module 16 and a web server that allows monitoring, remote diagnostics, viewing, logging errors and failures using the Web site. Network communication module 16 also allows to communicate with master slave devices such as a PC, PLC, input and output modules. The US control system shows some prompts on LED 13. All elements connected together (electronic modules and pneumatic valve modules) form the pneumatic valve terminal. Fig. 3 shows the general view of the designed pneumatic valve terminal built with five control valves 5/2 (five ways and two positions).

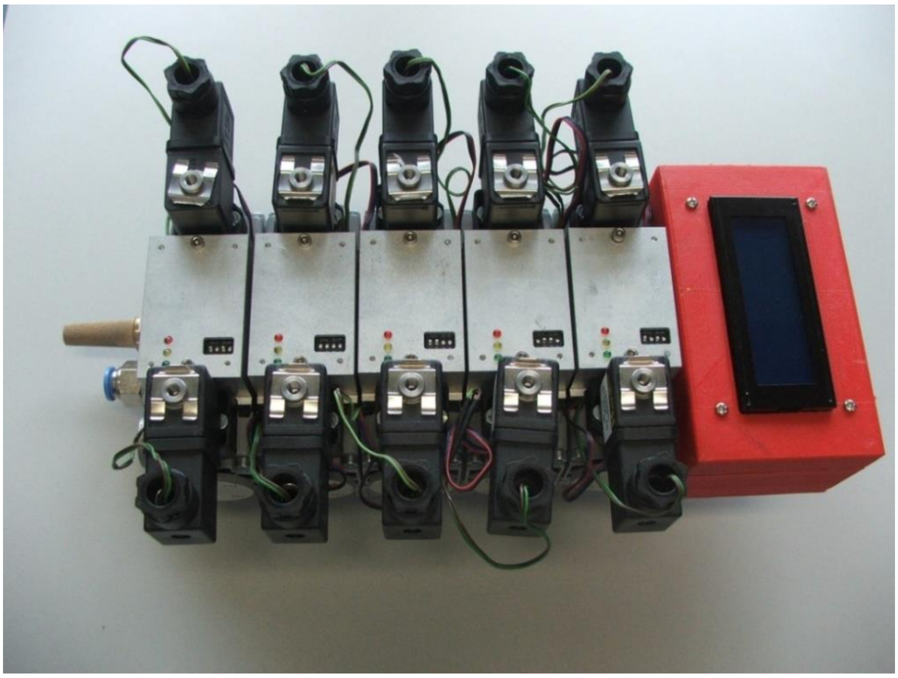

Fig. 3: The general view of the designed pneumatic valve terminal.

3. Conclusions

The authors conducted a market analysis of existing solutions manufacturers of pneumatic Bosch Rexroth, Festo, Asco Numatic, Parker, Hoerbiger Origa, Prema. Only Festo and Asco Numatic have equipped the valve terminals in a simplified diagnostic system. Designed pneumatic valve terminal has many features that set it apart from of competitive in the field of diagnostic activities: confirmation of the position of the piston valve in all positions, pressure measurement in 2 and 4 outputs, archiving of measurement data, possibility of control, remote control and monitoring. The last feature is ensured by the external communication with the device via the Internet. The communication system will operate on PROFINET or PROFIBUS allowing connection of ICT networks with distributed intelligent automation systems. Designed innovative modular pneumatic valve terminal with self-diagnosis, control system and industrial network communications meets all the assumptions. The pneumatic valve was presented at Poznan International Fair ITM 2013 and VI Fair of Pneumatics, Hydraulics, Drives and Controls PNEUMATICON 2013 in Kielce, where was recognized by the industry and won the gold medal. Pneumatic valve terminal can be used in the control, diagnosis and control of technological processes in which for safety or sensitivity reasons of the process is required to develop a specific states of actuators, confirmation switching the valves and monitoring the control system.

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