Mechatronic Laboratory Stand

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Abstract – **The paper presents the developed mechatronic system stand that allows to study the atmosphere parameters and conduct a number of laboratory works on mechatronic systems. The structure of the stand was built which includes a tube, a set of sensors, a set of devices impacting gas environment and means to process data from sensors. A physical model of the stand was developed. Specialized software that provides a representation of measured data in a user friendly manner and convenient means to influence the gas flow was designed and programmed. Methodological support (manuals and instructions) for the stand was created.**

Keywords – **pressure sensor, mechatronic system, physical model, sensors, gas environment, actuators, experimental research, LabView.**

I. INTRODUCTION

During the last several decade the technical systems have become smaller, cheaper, due to the use of modern components. One of the areas providing technical systems with modern element base is microelectromechanical systems industry. Advantages of microelectromechanical systems (MEMS) over traditional technical devices have caused their widespread and massive use [1-3]. Therefore hundreds of companies all over the world are involved in design and manufacture of MEMS and use them in technical systems.

A significant part of the market of MEMS devices occupy devices intended to process parameters of liquids and gases [6 - 8]. It can be stated that this number only increases every year.

Hydro- and gas elements of MEMS used in the following areas and devices [5]: lung ventilator; oxygen distribution system in hospitals; chemical microreactors; gas chromatographs; climate control rooms; gas leakage control systems, etc.

Accordingly, the study of physical processes of gas and hydro transitions, design of software systems to control such processes in microsystems is an urgent task.

II. DESIGN FEATURES OF THE STAND

Stand for study of gas parameters consists of several basic elements. Their schematic representation is shown in Fig.1. The basis of the stand is a plastic tube with an internal diameter of 46 mm and a length of 75 cm, which is designed to move gas from the one end of the tube to the opposite one. In addition, the pipe is a mounting element for sensors and other devices. At the input end of the pipe the subsystem that forms inbound gas stream with the specified parameters is placed. The layout includes a fan (1) and a set of four heaters (2). With these elements the flow rate, pressure and temperature in the channel can be changed. Thus, these two elements at the input end of the pipe provides a smooth change of the gas flow parameters.

At the other end of the tube the subsystem of sensors comprising temperature sensor Pt100 (3), a pair of pressure sensors HSCDRRN002NGAA5 with analog output (4), integrated pressure sensor MPXV5004DP (5), industrial motion and position sensors 180 deg RTY180HVEAX (6) (designed to change pressure in the pipe. To determine the gas spenditure we uses the device AWM720P1 (7) fixed to the end of the pipe. Accordingly the subsystem allows to measure parameters of the gas flow at the end of the pipe.

Subsystem of control and data processing includes the following equipment:

- 8 analog inputs modules SDM-8AI (SFAR);
- temperature sensor module MOD-1TE (SFAR);
- 4 digital outputs modules MOD-4DO (SFAR) – designed to control modlule relays controlling heaters (high power switch);
- Ethernet module MOD-ETH (SFAR).

Equipment is connected with a standard PC bus RS485, exchange of information is done via Modbus-RTU protocol.

III. DEVELOPEMENT OF STAND CONTROL INTERFACE

To convert the output voltage devices in SI units, and to control four heaters a scheme was designed in LabView, which is presented in Fig. 3. As some sensors have nonlinear characteristics of dependent measured value to the sensor output voltage, a polynomial interpolation function was used in LabView.

To present data from the sensors in a user-friendly format a management interface was developed in the LabView system and is presented in Fig. 4.

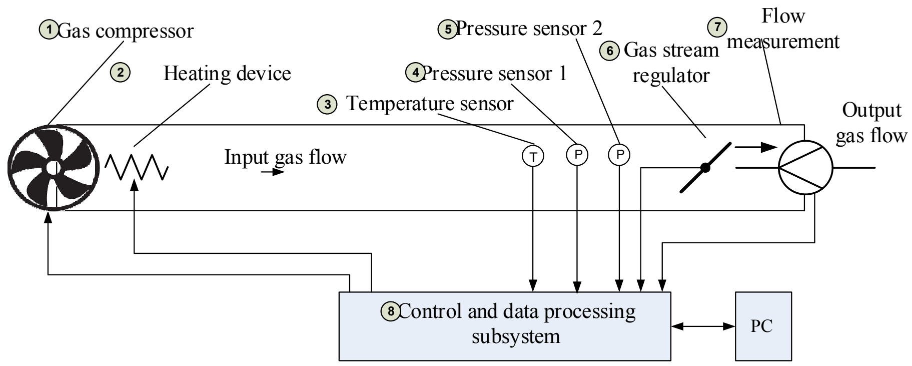

Fig.1. Schematic representation of the stand

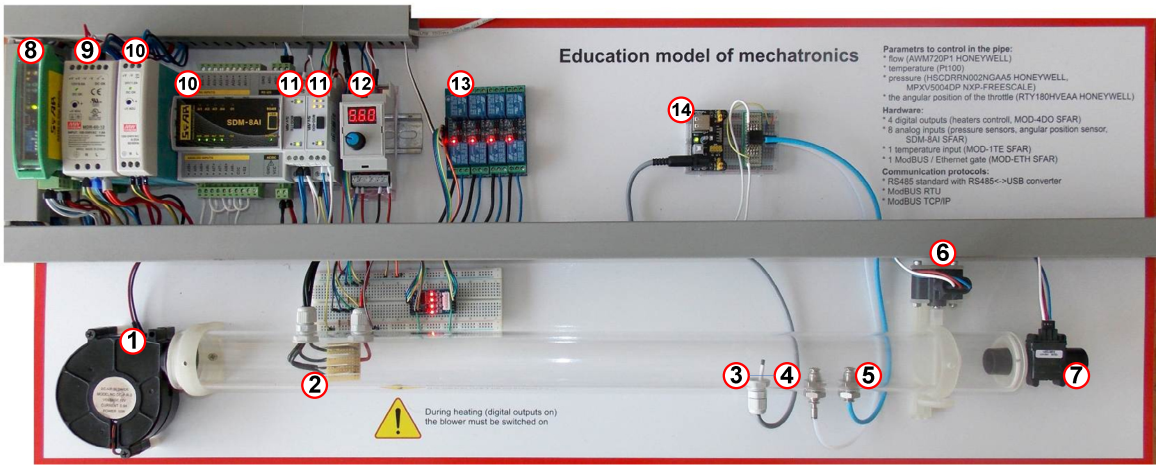

Fig. 2. Photo of laboratory mechatronic stand

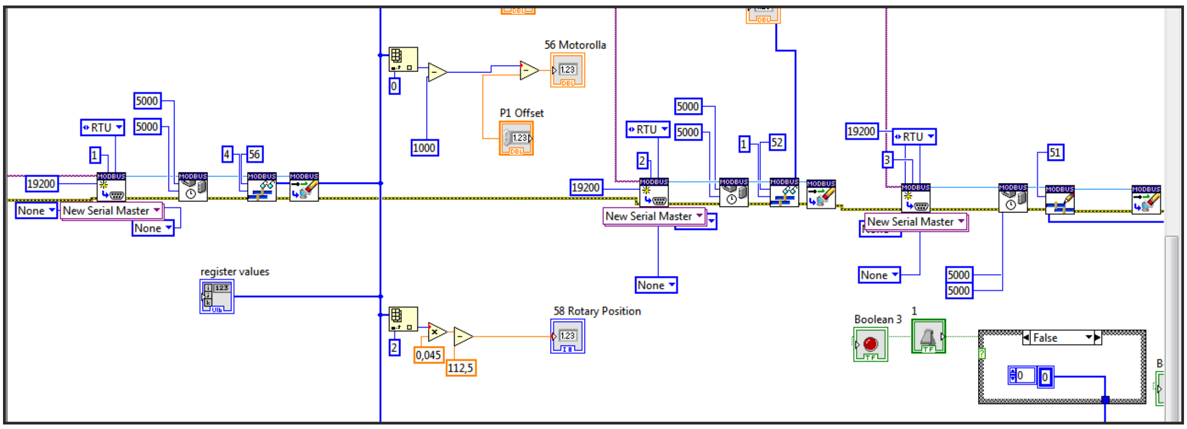

Fig.3. Control scheme of laboratory stand in the LabView system

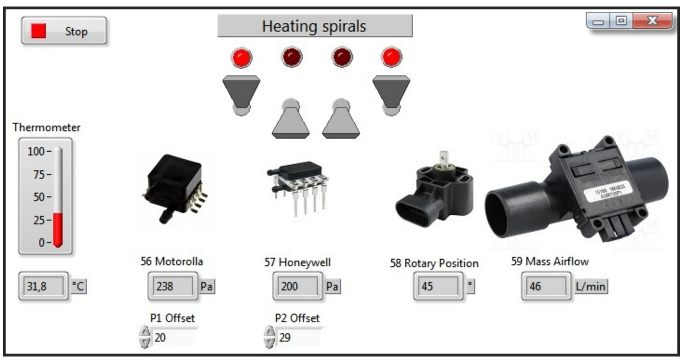

Fig.4. Stand control interface

III. APPLICABILITY

Laboratory stand is designed for use in both the educational process and research. The following options for its use are proposed:

- To learn to translate analog output signal form sensors into required units: a student takes with an accurate voltmeter results of sensor in millivolts, and having characteristics of all sensor determines pressure, temperature, gas flow and angle of the throttle in SI units. Then the teacher switches on a program developed in the LabView system and students test the calculated values with data from the program.
- Study of precision of pressure sensors. The task is to study the accuracy of the pressure sensor (connectivity of other pressure sensors to the designed stand is envisioned) at different temperatures and for different pressures. As an exemplary sensor to use pressure sensor from a catalog with the best characteristics of precision.
- Development and testing programs t control equipment through Modbus-RTU and Modbus TCP protocols.
- Study of heating model of smart home. The task is to develop a program that would support constant temperature using a temperature sensor for temperature control and Modbus-RTU or Modbus TCP protocols to control four heaters to keep constant temperature. A throttle damper in this case serves as an imitation of doors or windows. If it is open to more than 300, then restrict the possibility to switch heating on and issue a warning message).
- Development of models to study parameters of gas flow in the Comsol system while designing microsystems and comparing the obtained data with those obtained experimentally using the stand.

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VI. CONCLUSION

The laboratory stand was developed that allows to combine a study of many branches of science in one device. Laboratory model designed to study the accuracy of pressure sensors, student’s familiarization with such devices as flow measurement, angle position sensor and aims to show the principles of a TCP/IP module, RS485 bus, Modbus-RTU protocol, and modules that provide data transmition via this protocol.

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