CONSIDERATIONS ON THE DYNAMIC TESTING OF PNEUMATIC EQUIPMENT

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Abstract:*A large number of industrial applications use pneumatic driving systems, these encountering an increase in the past years. Although the performances of nowadays pneumatic equipment aresuperior to those recorded in the past decade, main functioning principles remain the same. The differences between current pneumatic equipment and installations and past ones are the materials and techniques used in their manufacturing, much more oriented to a better cost/quality ratio. Performance of a pneumatic driving system is important to be analysed, taking into consideration the compressibility of air and its changes in volume, pressure and density – related to temperature variation. Pneumatic systems are known to be very non-linear. This paper presents some considerations on the dynamic testing of pneumatic equipment – particularly used in a servo-pneumatic positioning system.*

Keywords*:dynamics, testing, servo-pneumatic, positioning*

1.Introduction

Pneumatic driving and positioning systems are gaining more space into the world of today's industry, being suitable for applications where it is not needed large power or where conventional driving systems cannot be used (such as ATEX environments).Problems arise in this type of systems due to the high compressibility of the working fluid (compressed air), causing problems when it is intended to develop an all-fluid (air) driving system.Most of the problems encountered in pneumatic systems appear clearly defined in dynamic operation.
When analysing the dynamic operation of a pneumatic system, it is a good practice to define the system's mathematical model and to simulate it using appropriate PC software. It must be taken into consideration that issues that appear in pneumatic systems occur in milliseconds. This will take a considerable amount of time, but it is less than buying all components of the system, assemble them and after that test the ensemble.
In this stage of the research, the authors have developed a servo-pneumatic positioning system schematic on which will be carried out experiments in the next stage of the research – these will be presented in the next paper.

2.Testing Stand Schematic

In order to draw some conclusions on the dynamic testing of pneumatic equipment, in our case a proportional directional valve used on a servo-pneumatic positioning system, it has been developed a schematic of a testing stand that can be presented by describing its main components: mechanic, pneumatic schematic and data acquisition. The schematic of the stand will be put into practice and presented in the next stage of the research.

2.1. Servo-Pneumatic Positioning System

The schematic of the testing system was based on a positioning system configuration, as given in Figure 1.
The servo-pneumatic positioning system is made of a pneumatic cylinder (8) (as seen on Figure 1), driven by a 5/3 proportional directional valve (7). The servo-cylinder has a stroke transducer

realized with an incremental encoder (9) that gives the feedback signal to the electronic controller (13). The positioning system has three pressure transducers; two of them are used for measuring the pressure on the connections of the pneumatic cylinder and one is used for monitoring the pressure value that is regulated by the pressure regulator (5). Also, the system has a safety valve, an air filter and a pressure gauge.

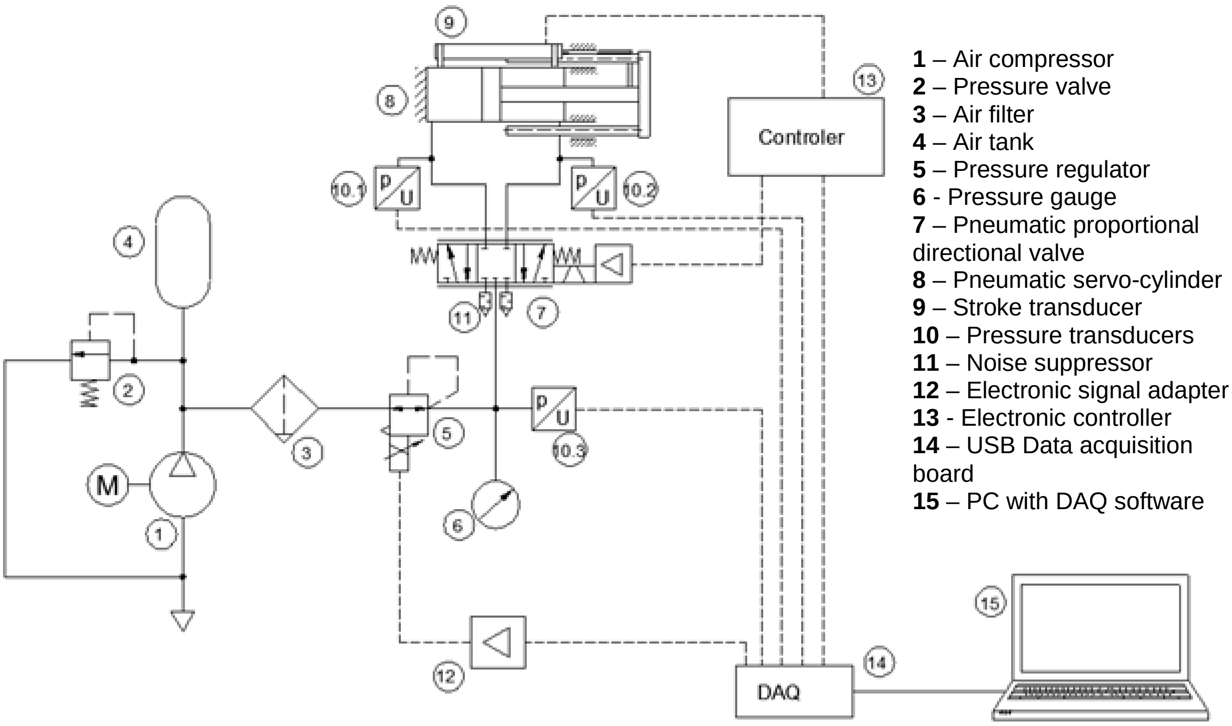

Figure 1 –Servo-pneumatic positioning system

In the figure above, it can be observed that the system is running in closed-loop, using an electronic controller (13) based on an 8-bit microcontroller. The stroke transducer (9) is mounted on the pneumatic servo-cylinder (8), the displacement being given by two quadrature signals that must be processed in order to extract the information about the displacement value and direction.

2.2. Electronic Controller

The electronic controller (13) in Figure 1 is using RISC architecture, 8-bit microcontroller, from the PIC family. The controller has to close the positioning loop, by measuring the displacement of the servo-cylinder (8) by means of the stroke transducer (9) and after processing - it outputs a drive signal to the proportional valve (7). The reference signal for the positioning loop it is given by the human operator, using the PC – DAQ – Virtual Instrument structure.
The electronic controller it comprises the followingcomponent units:

- analog and digital inputs, needed for adapting the level of external signals (stroke transducer and DAQ output) to the level required by the microcontroller;
- analog and digital outputs used for interfacing output signals of the microcontroller with the level needed by the pneumatic proportional valve;
- power supply, made using a dedicated switching integrated circuit, that uses a reduced number of external discrete components.

The analog input units have a resistive voltage divider for adapting the input voltage level to the level of the microcontroller’s analog input, while the digital inputs have a signalling LED and an in-series resistor for limiting the current on the microcontroller’s input. Analog output units use a MOSFET power transistor and a fast-recovery diode. The controller can be supplied from any DC voltage line between 9...36V, its current consumption being estimated to be under 1A. The microcontroller is supplied with 5V DC from the voltage regulator in the power supply, being protected against short-circuits and over currents.

2.3. Data Acquisition Structure

Along with the pneumatic schematic and electronic controller it is used a data acquisition structure, in order to acquire the system's operation in different cases. The DAQ structure uses a classical simultaneous parameter acquisition structure. The DAQ board (14) that will be used is National Instruments USB-6218. It will be used to complete the following tasks:

- data acquisition for the three pressure transducers (10);
- generate driving signal for the pneumatic pressure regulator (5), through the electronic signal adapter (12);
- generate reference signal for the closed-loop position controller.

a. photo

- 32 single-ended or 16 differential analog inputs;
- 16-bit resolution;
- 2 x 16-bit analog outputs;
- sampling rate of 260kS/s;
- input voltage range: -10…10V;
- 8 TTL input channels and 8 TTL output channels;
- on-board sample memory: 4095 samples;
- digital trigger.

b. technical features

Figure 2 – NI DAQ-6218 board

For the next stage of the research, it will be used a virtual instrument (VI), that will probably need furthermore improvements – given by the nature of the experimental activities. In the Figure 3 it is shown the user panel of the first version of the VI (before experimenting), developed using the LabVIEW environment.

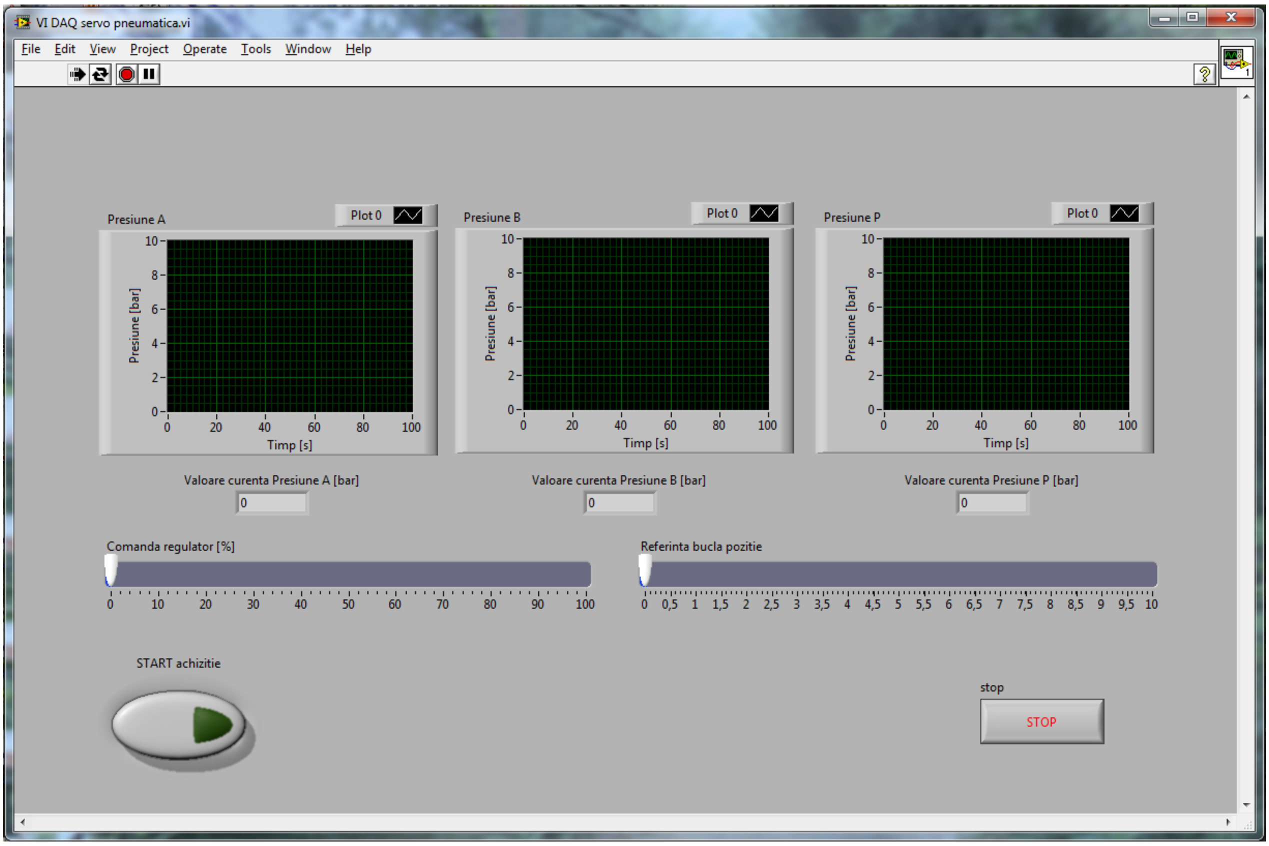

Figure 3 –User interface for control/monitoring VI

The VI must be able to perform the following tasks:

- acquisition of experimental parameters;
- data conditioning;
- data storage;
- graphical display for the variation of experimental parameters;
- graphical interface with the user.

3. Conclusions

To design an efficient pneumatic driving system it is necessary,in most cases, to make a preliminary analysis of its dynamic behaviour,otherwise, it is possible that the pneumatic installation/system will not function as initially expected. This situation can lead to a significant increase in costs and time to make the system function as intended.

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