DATA AQUISITION SYSTEM FOR STATIC AND DYNAMIC TESTING OF PNEUMATIC AXES

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Abstract: *Data acquisition and virtual instrumentation entered the field of industrial applications many years ago, gaining more and more field over classical measurement and control systems. The authors propose a simple data acquisition system designed for static and dynamic laboratory tests on pneumatic axes. One noticeable advantage of the data acquisition system is its flexibility, allowing the users to easily reconfigure and adapt it to some changes in pneumatic axes' configuration. This article comes as a continuation of the one published in the previous number of the magazine regarding the dynamic testing of pneumatic axes.*

Keywords*: data acquisition, static, dynamic, pneumatic, testing*

1. Introduction

Static and dynamic performances of pneumatic system have increased more and more during time, challenging engineers to develop new control strategies that use pneumatic axes in a more energy efficient way. Basically, there can be used microcontroller/microprocessor electronic modules, PLCs, standardized dedicated measurement and control modules or, much more flexible, data acquisition and control systems. Main functioning principles of the pneumatic axes remain the same, but their control need have changed.
The article proposes a simple configuration for a data acquisition system (DAQ system), used in static and dynamic testing of pneumatic axes. The DAQ system was used in the study of a pneumatic suspension system, as given in Figure 2, with a high significance for the automotive field because its structure exemplifies the idea that is used when designing a control system for ground clearance of trucks or utility vehicles depending on their load.

2. Experimental Stand

The schematic of the experimental stand that was constructed in the Pneumatic Laboratory of the Hydraulics and Pneumatics Research Institute (INOE 2000 – IHP) is given in Figure 1. This system comprises the data acquisition structure that the authors propose, this being described below.
In Figure 2 there can be observed a pneumatic actuator that is used in pneumatic spring configuration, this being mounted on each wheel of the vehicle. The stroke transducer (9) of the pneumatic cylinder's rod (7) is giving a signal for the control loop that manages the supply with compressed air depending on the load. In this case, the pressure in the pneumatic actuator will increase or decrease according to load variation. The purpose is to maintain at a constant value the ground clearance of the vehicle.
In Figure 1, there is given the characteristic diagram of the pneumatic spring realized with the pneumatic actuator (9), at two values of working pressures.

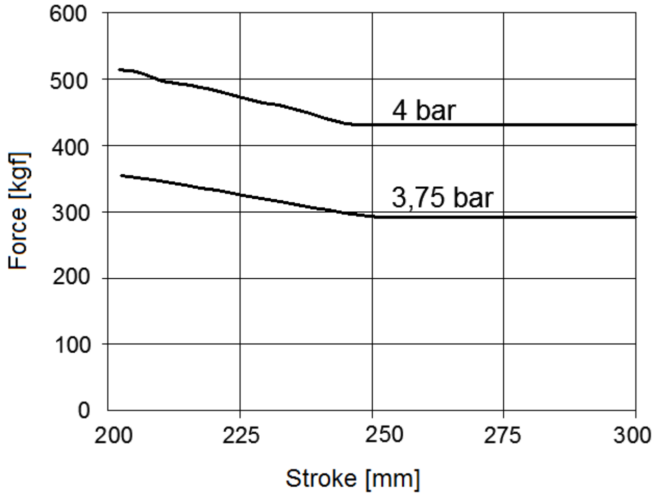

Figure 1 - Characteristic diagram of the pneumatic spring.

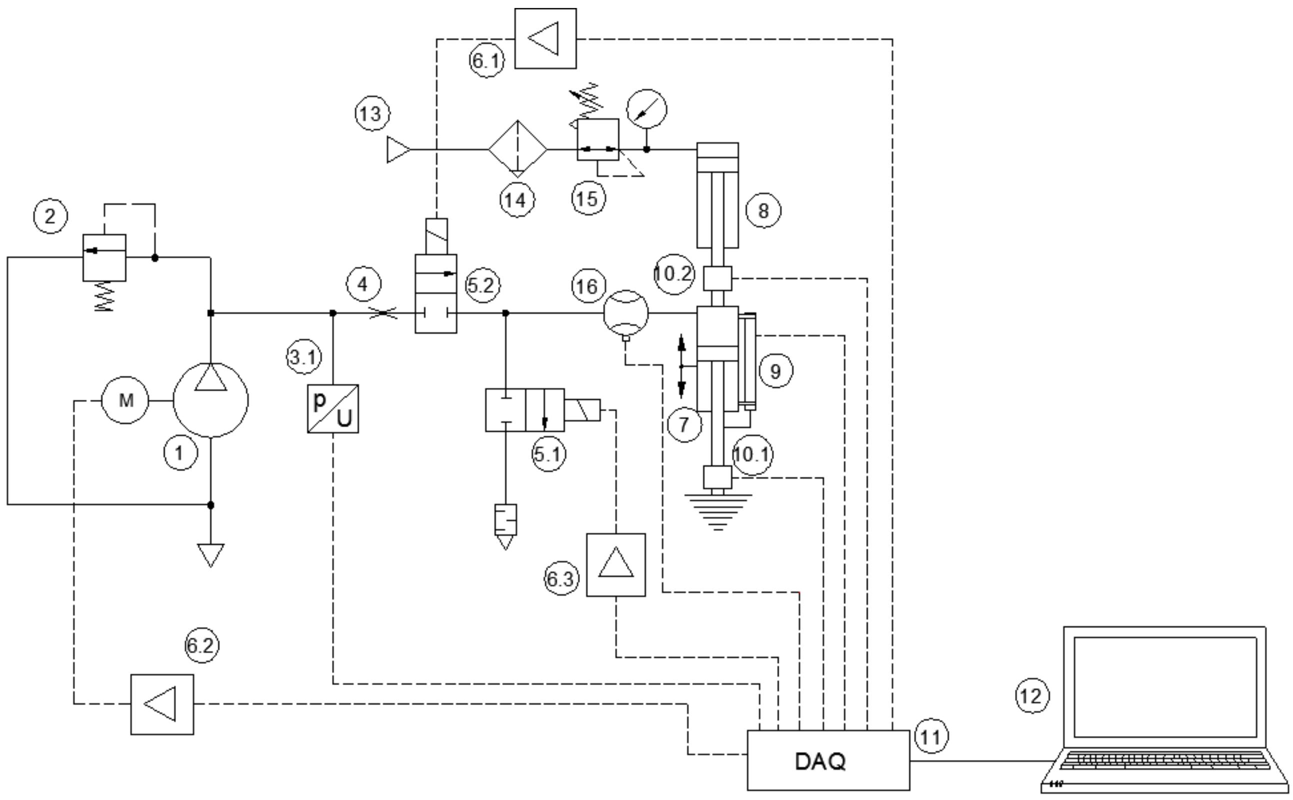

Figure 2 – Schematic of the system, including data acquisition.

In Figure 2, we have the following:

1 – Air compressor;
2 – Safety valve;
3 – Pressure transducer;
4 – Throttle valve;
5 – 2/2 pneumatic directional valves;
6 – Electronic signal adapter;
7 – Pneumatic cylinder;
8 – Pneumatic cylinder acting as load;
9 – Stroke transducer;
10 – Force transducer;
11 – USB data acquisition board;
12 – PC and data acquisition software;
13 – Compressed air source;
14 – Air filter;
15 – Pressure regulator with manometer;
16 – Flow transducer.

The experimentation of the system that the authors propose is made using the schematic given in Figure 2, in which a pneumatic actuator (8) is driving with 400kgf the pneumatic cylinder (7), acting as a vertical pneumatic suspension. After starting the data acquisition software, the current load value is increased with 100kgf more. In this case, there can be observed that the system starts pumping air in order to keep the pneumatic cylinder in the prescribed position.
Ten seconds after starting data acquisition, the supplemental load of 100kgf it is being decreased, observing an increase in the stroke of the pneumatic cylinder. The system will bring the pneumatic actuator in the prescribed position in almost 2 seconds from eliminating the excess pressure using the pneumatic directional valve (5.1). The evolution of the pneumatic cylinder stroke during the experiments is given in Figure 4.
The flow variation that enters and exits the pneumatic actuator of the pneumatic suspension system is given in Figure 5, and the pressure variation in Figure 6. When the load increases, then the pressure increases also from 4,3bar to 5,4 bar. When the supplementary load decreases, the pressure is stabilizing again to 4,3bar. As a convention, in the diagram given in Figure 5, it is considered that the air that enters the actuator has a negative sign while the one that exists has a positive sign.
When the load was increased, the air flow evacuated from the actuator had a peak value of 375l/min. When the supplementary load was eliminated, the pressure in the actuator being too high for the nominal load, caused the actuator to extend conducting to an instantaneous flow of air of -437l/min. After this sequence the air flow has a value of almost 60 l/min until the actuator regains the prescribed position.

3. Data Acquisition System

The authors propose a simple data acquisition structure, in a classical configuration of simultaneous parameters acquiring. The system comprises not only the data acquisition board, PC and software but the transducers, their measurement amplifiers, electronic power source and voltage stabilizer.
Starting from the functional schematic of the pneumatic system and analyzing the measurement and control needs there was developed a data acquisition software using the LabView environment – practically is a virtual instrument.
The front panel of the virtual instrument used for data acquisition and control is given in Figure 3 (before experimenting).
Main functions that the virtual instrument must assure are:

- acquisition of parameter values
- data conditioning and processing;
- data storage;
- graphical interface through buttons, sliders, indicators etc., with the user;
- graphical display of parameters' variation;
- closed loop control of the "ground clearance of the vehicle", simulated in laboratory conditions;
- ON/OFF control of the pneumatic directional valves;
- ON/OFF control of the electric motor of the air compressor;
- START/STOP data acquisition.

The data acquisition board (14) in Figure 2 it was a National Instruments board, with USB connection: USB 6218. The board has the following technical parameters:

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

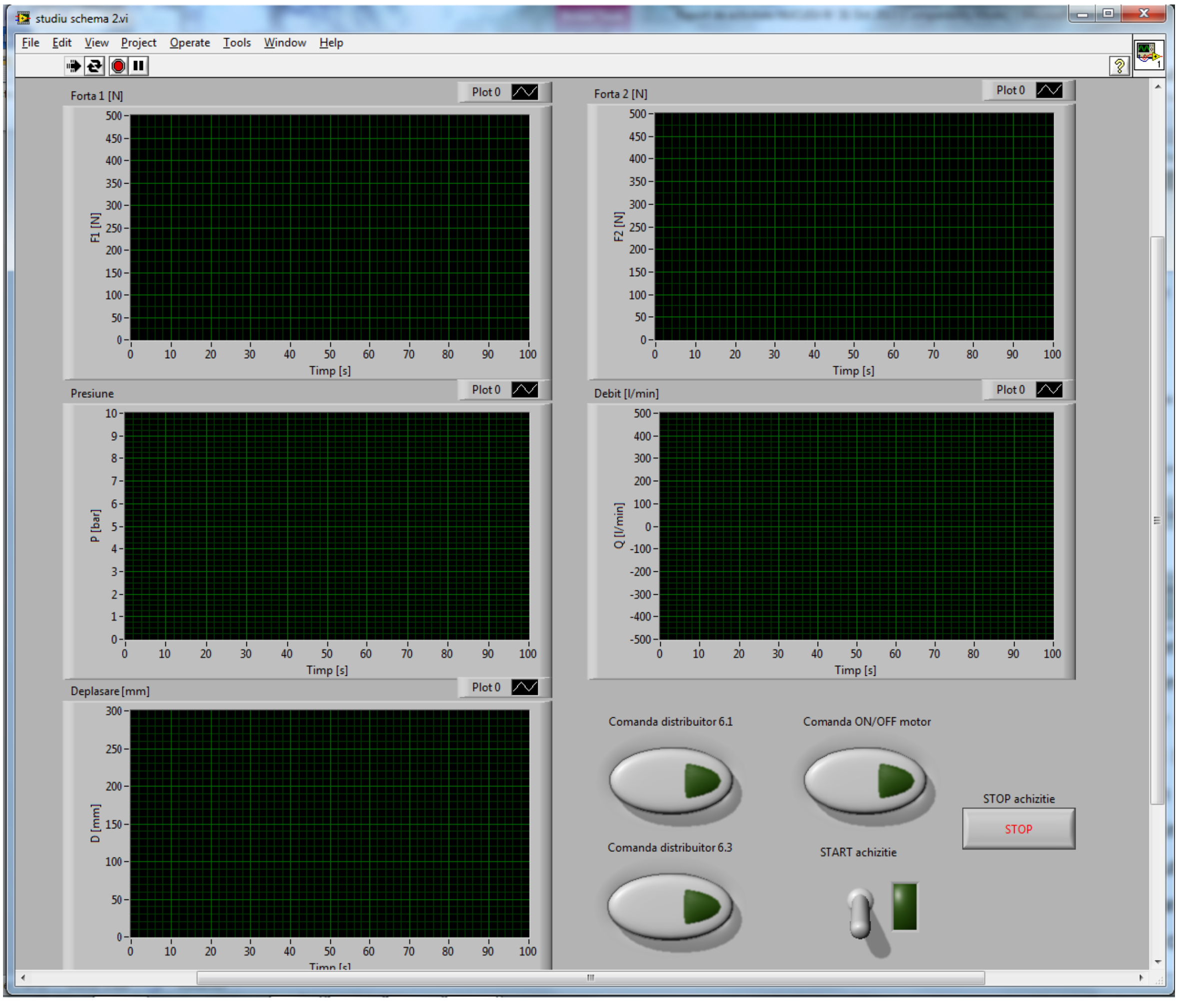

Figure 3 – Data acquisition and control virtual instrument.

4. Practical results

The experimental stand was assembled in laboratory conditions according to the schematic given in Figure 2. After setting up and interconnecting the mechanical, electronic and data acquisition structures there were run a series of experimentations that conducted to the diagrams presented below.

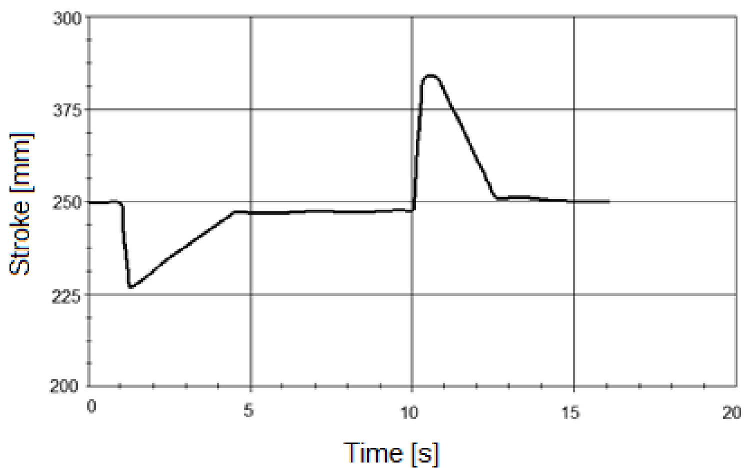

Figure 4 – Stroke diagram of the pneumatic actuator (9).

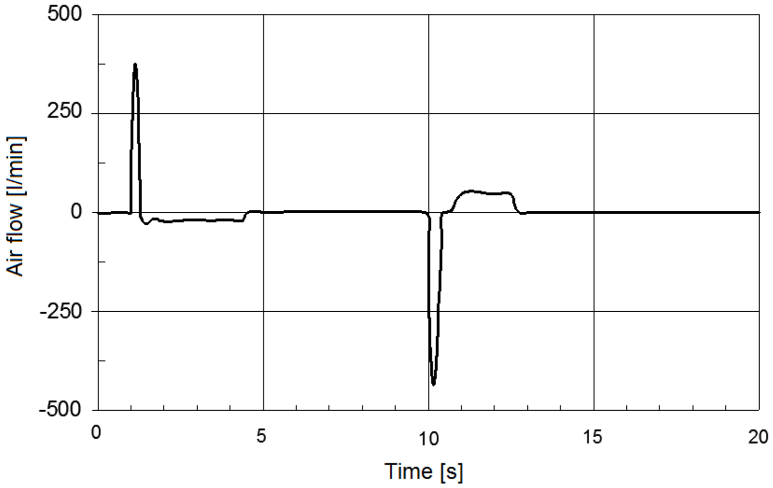

Figure 5 – Air flow variation diagram in the pneumatic actuator (9).

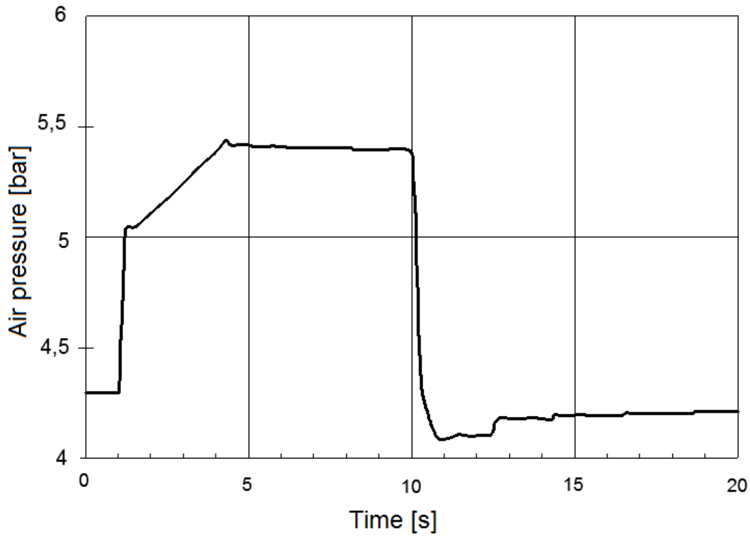

Figure 6 – Air pressure variation diagram in the pneumatic actuator (9).

5. Conclusions

Sometimes, dynamic behavior of a pneumatic driving system cannot be anticipated and must be studied thoroughly as early as in the design phase, otherwise there can occur time and money losses in case the proposed solution does not function properly. Thus, when designing a pneumatic driving system for a specific application, it is advisable to make a preliminary analysis through computer simulation and experimentations of a functional model, as presented above.

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