VIRTUAL INSTRUMENT FOR PLOTTING SERVO-VALVES CHARACTERISTICS AFTER SIGNIFICANT MAINTENANCE OPERATIONS

Radu RĂDOI[1], Iulian DUȚU[2]

[1] Hydraulics and Pneumatics Research Institute, radoi.ihp@fluidas.ro

[2] Hydraulics and Pneumatics Research Institute, dutu.ihp@fluidas.ro

Abstract: *Maintenance using virtual instrumentation for diagnosis has entered the field of servo-hydraulics few years ago, offering new accurate methods and concepts. The authors have developed a virtual instrument for plotting servo-valves characteristics, achieving larger flexibility and versatility compared to classic methods, thus shortening the time allocated for reconfiguration and recalibration of devices and equipments mounted on a specific test stand. Proposed virtual instrument acquires, conditions, processes and stores data automatically, using structured database model, thus reducing the intervention of the human operator, increasing overall accuracy. The virtual instrument that the authors propose has large integration capabilities into informatics systems and can be set to work with other types of hydraulic equipment besides servo-valves.*

Keywords*: servo-valve, virtual instrument, test stand*

1. Introduction

In present, static and dynamic testing of servo-valves it's done by using complex testing stands and installations with large number of electro-hydraulic equipment connected together thus maximizing the risk of being influenced by perturbations such as electromagnetic interferences, noises, unwanted vibrations and electrostatic discharges in the measurement circuits, all conducting to wrong results or damage of ESD sensitive equipment. The authors have developed and tested in laboratory conditions a virtual instrument for plotting the functional characteristic of servo-valves (hereinafter referred as VI) using a simplified hydraulic system.

Studying the basics of virtual instrumentation field, it can be seen that a VI has two main components: hardware and software, comprising switches, software buttons, knobs, sliders, digital indicators and so on, having a front panel that can be modified very easy. Virtual instrumentation design implies having a personal computer with specialized extension boards (such as data acquisition boards) and a software environment that together simulates the features and the operation of one device or measurement system. Transducers, analog to digital converters and the usage of data conditioning electronic circuits is mandatory. It can be said that one difference between virtual instrumentation and classic testing is that all control functions are automated and centralized using a personal computer with specific software.

2. Failure Causes in Servo-Valves

When a malfunction occurs in a hydraulic system and a servo-valve is the main cause of it, the operator must unmount it from the installation and put it on a test stand using either classic testing or modern technologies. For reducing downtime of the hydraulic system the operator can replace the defective servo-valve with another one with same functional parameters - if available. After mounting the defective servo-valve on the test stand the operator must perform certain tests in order to identify the cause of failure. It has been documented that common symptoms of defective servo-valves are:

- nozzles clogged, when the fluid flows only in one way, when applying an electric command;
- broken coil, when the servo-valve does not respond to any electric command;
- shifted null point, when there is flow without an electric command;

- asymmetry, having unequal flow values at equal electrical command for both polarities;
- high wear of spool and sleeve, when high flow that cannot be canceled by adjustments occurs in null point;
- large hysteresis when reversing electrical control because of the friction between the spool and sleeve due to residues present in hydraulic oil.

Servo-valves must be diagnosed only by qualified personnel.

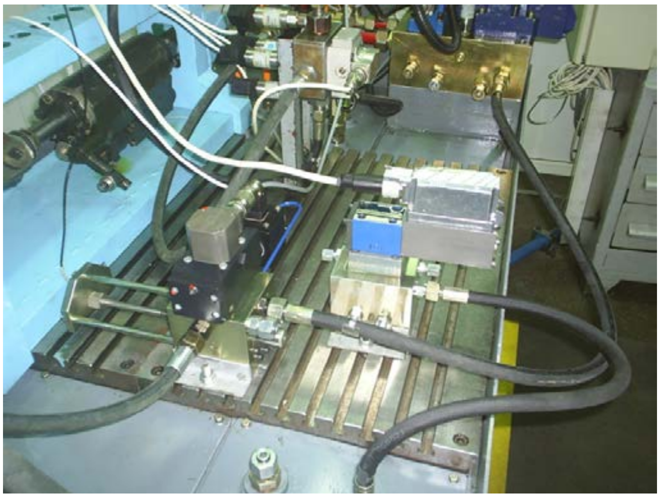

Fig. 1 – Electro-hydraulic stand for optimization of servo-valves

Maximum operating pressure of the test stand is 315 [bar] and the nominal flow is 50 [l/min]. The servo-valve that the authors used has the following characteristics:

- valve size: 04;
- nominal flow: 10 [l/min];
- nominal pressure: 315 [bar];
- electrical command current: ± 20 [mA].

The VI described in this article is using a PC with two data acquisition boards and a control program for testing stand's functions along with automated data acquisition, numerical filtration and storage of test data. It can be noticed that the human operator has a reduced interaction with the stand having a positive impact on system's repeatability and accuracy along with shortening time needed for reconfiguration of physical connections between hydraulic and electronic devices. The VI is flexible and supports fast recalibration and reconfiguration, having the possibility to define and store certain test configurations.

The VI can perform different servo-valves tests; most important ones are step response and sinusoidal signal characteristics. Key parameter values for plotting step response characteristic are given by rise time, stabilization time and overshoot value. When plotting the sinusoidal signal characteristic it is necessary to draw the dependencies between: amplitude and frequency, phase and frequency and to plot Bode diagrams.

Another module of the VI generates test signals needed for both types of characteristics while other module acquires experimental data, in count of 25000 samples per channel. Test signal's parameters and number of samples can be modified using VI's configuration module. Experimental data are processed automatically and then displayed on a graphical control placed on the front panel of the VI.

Interacting with the VI is simple and intuitive: after displaying the main panel it will be initialized the data acquisition boards – including proper calibration and scaling - followed by setting all program constants. Selected type of test will begin when the human operator clicks on the START button – running signal generation, data acquisition, numeric filtering, data processing and storage on a column-separated values .DAT file, for later processing.

The VI will plot the tested servo-valve's characteristic checking the following:

- hysteresis, defined as the difference between the command size, usually a current within ±20 [mA] supplied by an electronic module with input signal of ±10 V, required to achieve a flow rate variation in upwards with the input level , from minimum to maximum, and the control level necessary to obtain same flow rate at a command size variation in downward from maximum to minimum;
- linearity, determined by the maximum value of difference between command level from real diagram and that obtained on theoretical diagram (drawn between extreme points from the hysteresis diagram);
- repeatability, maximum difference between values obtained at the same level of electric command value;
- sensitivity, defined by the ratio between output value variation and the corresponding variation of input value, in case of a linear static characteristic;
- the characteristic of flow rate – command level from input (usually a current within ±20 [mA] supplied by an electronic module with input signal of ±10 V) at a constant pressure drop;
- the pressure-flow characteristic given at a constant electric command;
- minimum operating pressure, which is the lowest value at which the flow can be adjusted on the entire operating range.

3. DAQ Structure

Proposed data acquisition structure is simple and classical having simultaneous parameters acquisition, comprising the following:

- specific sensors and transducers (force, flow, pressure);
- measurement amplifiers for system’s transducers;
- data acquisition board (technical characteristics are given below);
- virtual instrument;
- electric power source and voltage stabilizer.

During the test process, the data acquisition structure will perform the following:

- acquisition of parameters values;
- conditioning and processing acquired data;
- storage of data;
- graphical interface with human operator;
- graphical display of parameter variation or user defined characteristics.

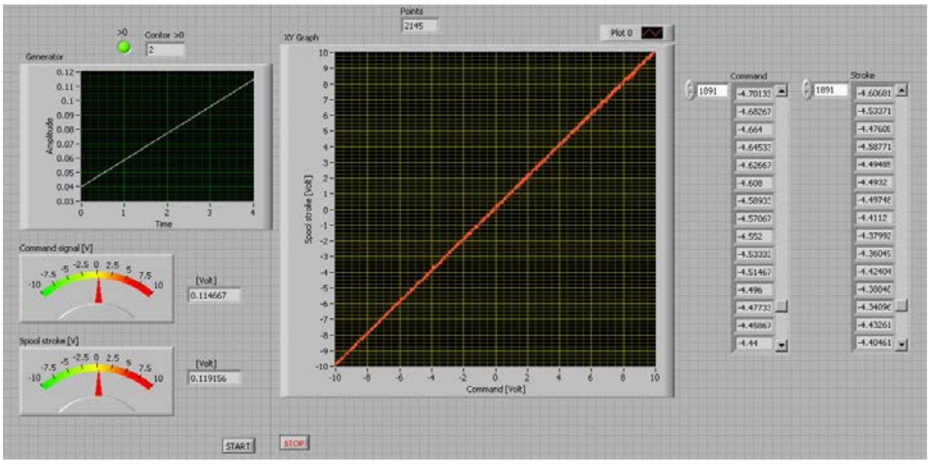

Fig. 2 – VI’s main panel

The data acquisition board used is National Instruments USB-6218, with the following technical features:

- 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.

The human operator can perform specific static and dynamic tests on servo-valves - most significant are step response and dynamic response at sinusoidal signal input.

The authors have developed the virtual instrument using LabView, because of its easy integration with measurement and control processes.

The VI can perform static and dynamic tests with a minimum need of human operator intervention. Experimental data for the selected test are acquired continuously after pressing the START button on main panel of the VI. Data are displayed on a graphic control.

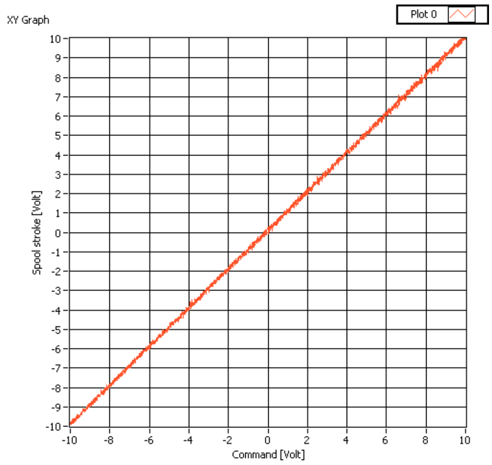

Fig. 3 – Adjustment characteristic of a servo-valve

4. Conclusions

The plotting of functional characteristics of servo-valves using presented VI allows operators to evaluate the functioning state after maintenance operations. Due to its modularity, the VI is easy to be interfaced with common electro-hydraulic systems.

Supply power for electronic modules can be taken from main electrical installation of the hydraulic system or test stand, current consumption being low.

By combining electronic modules and informatics technologies it can be simplified the implementation and reconfiguration of servo-hydraulic systems, using specific transducers, data acquisition boards, and virtual instrumentation.

REFERENCES

[1] D.I. Guta, C. Dumitrescu, I.Lepadatu, C.Cristescu: *Experimental identification of electrohydraulic servomechanisms with virtual instruments technique*, HIDRAULICA no.3/2010, pp.49-56.

[2] A. Drumea, P. Svasta, *Microcontrolere pe 8 biti utilizabile în comanda şi controlul dispozitivelor hidraulice*, Salonul National de Hidraulică şi Pneumatică HERVEX2002, 13-16 noiembrie 2002, Calimanesti-Caciulata, pp. 124-128.

[3] Guillon, M., *Commande et asservissement hydrauliques et electrohydrauliques*, Editions Lavoisier, Paris, 1996.

[4] P. Drumea, M. Blejan, A. Mirea, I. Ilie, G.Matache, *Virtual Instrument Designed For Dynamic Tests Of Electro-Hydraulic Devices,* ISSE 2007, pp.293-297.

[5] Information on http://www.ni.com.